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INSTITUTE FOR DEFENSE ANALYSES

The Major Causes of Cost Growth in Defense Acquisition

Volume II: Main Body

Gene Porter, Project Leader
Brian Gladstone
C. Vance Gordon
Nicholas Karvonides
R. Royce Kneece, Jr.
Jay Mandelbaum
William D. O'Neil

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About this Publication

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I. INTRODUCTION

Cost growth in Department of Defense (DoD) acquisition programs has been of great concern to virtually every administration and Congress since the 1970s. Periodically, new procedures are adopted to control it, new horror stories emerge, and new studies are undertaken to reveal its causes. The latest surge of concern began in 2008, with the release of a Government Accountability Office (GAO) report that DoD's Major Defense Acquisition Programs (MDAPs) had grown in cost by an estimated $296 billion.[1] With a new administration on the horizon, the Director for Acquisition Resources and Analysis, in the office of Under Secretary of Defense for Acquisition, Technology and Logistics (OUSD(AT&L)), turned to IDA for an in-depth examination of the causes of DoD acquisition cost growth.

The report is organized into three volumes. Volume I is a self-contained executive summary; volume II (this volume) describes the methodology employed in the study, summarizes the formal acquisition process and available data sources, and presents the findings, conclusions, and recommendations which have emerged to the study team through examination of the 11 programs. They are supported with examples from the 11 programs. Volume III consists of 13 appendices, one for each of the programs examined, with a narrative of the program's history and discussion of how the insights supporting the findings and conclusions emerged, a list of references, and a list of acronyms and abbreviations.

In this introductory chapter, we describe how this study differs from and builds upon its predecessors, provide an overview of the Defense acquisition system and the historical forces that shaped it, and briefly discuss the strengths and weaknesses of the data that serve as the basis for our analysis.

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[1] Government Accountability Office, "Fundamental Changes are Needed to Improve Weapon Program Outcomes," September, 2008, GAO-08-1159T. While the accuracy of this figure is not disputed, the interpretation of it has been. A March 31, 2009, memorandum from the USD(AT&L) to the Secretary of Defense says: "…I would suggest that the number is misleading, out-of-date, and largely irrelevant to the current management of DoD programs."

A. WHY IS THIS STUDY DIFFERENT?

This report identifies the primary causes of major cost growth through case studies of 11 MDAPs and offers recommendations for better controlling cost growth in future programs. It identifies, with the full benefit of hindsight, particular decisions and mistakes that resulted in cost growth, not with the intent of blaming individuals, but to illuminate problems in the DoD acquisition process that point the way to the recommendations for improvements. In this context it is important that the reader keep in mind that successful Defense acquisitions depend on the efforts of many participants in the process. The Defense Acquisition Executive (DAE), to be sure, has primary responsibility for the key decisions on the major programs and for the overall functioning of the acquisition system, but the quality and successful implementation of his decisions depend on many others—the supporting staffs in the Office of the Secretary of Defense (OSD), the Joint Staff, the Services, including the Service Acquisition Executives (SAEs), government program managers and contracting officials, and defense contractors. This large ensemble of participants must work well together as a team to provide the information and analyses that support good decisions and carry them out once they are made.

Moreover, decisions about MDAPs touch on the core interests of important stakeholders outside the formal acquisition process both inside and outside DoD. The DAE must exercise a keen understanding of those forces, including the transcendental goals of the administration of which he is a key member. This report is intended, not to indict the past, but to help future decision-makers avoid the pitfalls it identifies.

This study sought a deeper understanding of the decisions and mistakes that contribute to cost growth through an in-depth examination selected MDAPs. Working with the sponsor, IDA selected 11 important programs that had entered full-scale engineering development between 1995 and 2006 and subsequently experienced cost growth that breached or nearly breached the thresholds established by the Nunn-McCurdy Act.[2] The study team assembled histories of the programs by examining official records and through interviews with former senior acquisition officials and their staffs, cost estimators and analysts in the Office of the Director Program Analysis and Evaluation (PA&E—recently renamed Cost Assessment and Program Evaluation

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[2] The Nunn-McCurdy Act requires the Department to make a new determination of need and funding adequacy for programs whose projected costs rise 25% above their baseline estimates.

(CAPE)), and personnel in the military departments. This report presents the findings of those analyses, general conclusions regarding the sources and contributing factors of cost growth, and recommendations on how to constrain acquisition cost growth in the future.

We relied heavily on Selected Acquisition Reports,[3] Defense Acquisition Executive System (DAES) reports, and Acquisition Decision Memoranda (ADMs). Additional sources included GAO reports, Congressional Research Service and Congressional Budget Office studies, documentation from program management offices (PMOs) obtained from OUSD(AT&L) staff, and miscellaneous sources on individual programs.

Over 100 people were interviewed. The general ground rule was "non-attribution." The range of interviewees spanned from senior defense decision-makers (e.g. former USD (AT&L)s and principal deputies), through mid-level managers, to staff action officers. Most interviews were with people in OUSD(AT&L) and the Cost Analysis Improvement Group (CAIG)[4] but interviews were also conducted with personnel in other OSD offices, including offices under the PA&E Director's supervision. A number of key people in the Military Services were included, but contact with current PMOs was deliberately limited.[5] While respecting the "non-attribution" rule, we will attempt, in so far as possible in this document, to indicate when a finding or conclusion is based on the informed opinions of interviewees. In general, we sought corroboration from at least two independent sources before drawing conclusions based on the opinions of interviewees.

In addition, some of the members of the IDA study team were familiar with some of the programs based on their past experience in government and industry.

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3 Because considerable care goes into preparing the SAR reports to Congress, and no other systematic and accessible tracking system exists, the SAR data base is, in almost all cases, the singular and most definitive source of information for DoD cost growth studies.

4 The Weapon Systems Acquisition Reform Act of 2009 directed a reorganization of the CAIG, which is to be renamed as Director of Cost Assessment and Program Evaluation (with a Deputy Director for Program Evaluation). This report, however, was conducted for the most part before the law was implemented, so the terminology in effect at the time will be employed.

5 The JSF Program Office was quite helpful, however.

B. THE SELECTED PROGRAMS

All 11 programs, shown in Table 1 with their current status, entered full-scale development at least four years ago.[6]

Table 1. Acquisition Programs Examined

System	*Date of MS-II/B Approval*	*Current Status*
Armed Reconnaissance Helicopter (ARH)	Jul-05	Cancelled
Expeditionary Fighting Vehicle (EFV)	Dec-00	Pre-MS C
Future Combat System (FCS)	May-03	Pre-MS C (Restructured)
Global Hawk	Feb-01	LRIP*
Joint Air-to-Surface Standoff Missile (JASSM)	Nov-98	LRIP
Joint Strike Fighter (JSF)	Oct-01	LRIP -4
Joint Tactical Radio System (JTRS)-Ground Mobile Radio (GMR)	Jun-02	Pre-MS C
Littoral Combat Ship (LCS)	May-04**	Pre-MS B
Amphibious Transport Dock (LPD-17)	Jun-96	In production
Space-Based Infrared Satellite-High (SBIRS)	Oct-96	Pre-MS C
Warfighter Information Network-Tactical (WIN-T)	Jul-03	Pre-MS C***

** Low-rate initial production ** Milestone A *** Restructured. Original WIN-T program now divided into two programs-- WIN-T Increment 2 and WIN-T Increment-3*

6 We use this term generically, since the name has changed several times—from Engineering and Manufacturing Development (EMD) to System Development and Demonstration (SDD) and back again. We will use either EMD or SDD, whichever term was in use at the time. Likewise, when discussing specific systems we will refer to the nomenclature in use at the time.

C. THE COST METRIC

Normally cost growth is measured from the point when the program is approved for entry into full-scale development. The decision point is now known as Milestone B (MS B), and is generally the point at which the first full cost reports are provided to the Congress. This is the point at which the program becomes what is known as a "program of record" within the acquisition process. In one program, littoral combat ship (LCS), MS B has not yet occurred, and cost growth is measured from Milestone A (MS A), as it is with most other ship programs.[7] For certain other programs (e.g., Joint Strike Fighter (JSF)) pre-milestone II or B cost estimates are of interest.

We used Program Acquisition Unit Cost (PAUC) as the primary metric for cost growth. PAUC is the sum of all investment costs (RDT&E, Procurement, and Military Construction) in constant-year dollars divided by the acquisition quantity planned at the time of the estimate. The PAUC is the single most representative measure for comparing cost growth in programs with highly diverse, particularly with regard to the relative magnitudes of R&D and production costs. This diversity reflects the broad span from programs that cost a lot to develop, but entail the production of only a few "end items" such as satellites and large new software programs that run on existing or low-cost equipment, to programs entailing thousands of new end items after only a limited amount of development, such as new models of expendable weapons.

Figure 1 depicts the cost growth to date in the 11 programs.

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[7] Ship programs are formally started and tracked from MS A primarily because that is the point of commitment to actually build and field the first ship.

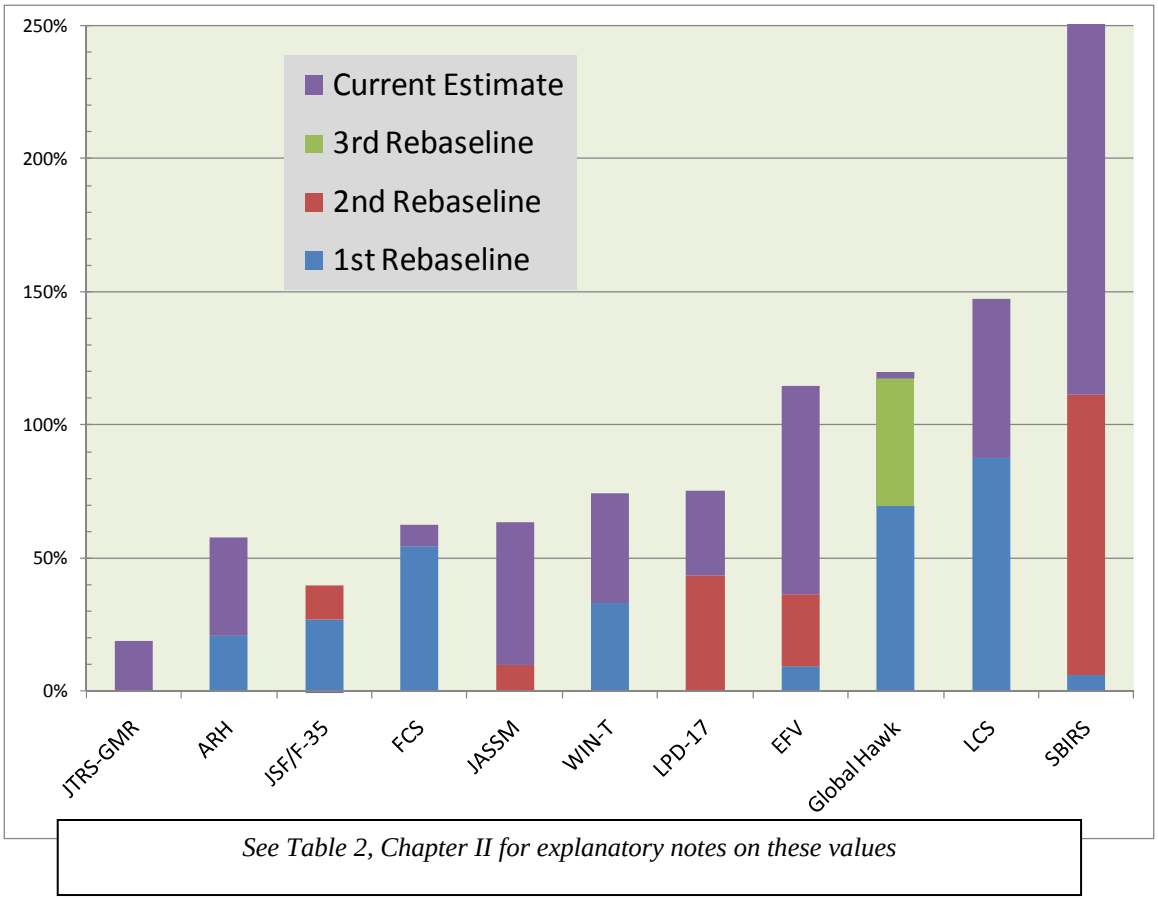

Figure 1. Cost Growth in Selected Acquisition Programs

Except for LCS, the chart displays PAUC growth from each program's initial formal estimate to its most recent estimate. For those programs that have been re-baselined,[8] the cost increments are shown for each revision. Where the current estimate exceeds the most recent baseline estimate, the difference is shown as an additional increment. Programs are re-baselined to acknowledge significant changes in scope, other irreversible cost growth and/or schedule slippage. A program may hold to its MS B baseline for an extended period either because it has not encountered significant cost or schedule problems or because the problems go unrecognized or are ignored. Examples of the latter cases will be discussed in Chapter II.

The average PAUC growth for these 11 programs was 90%, ranging from a low of 19% for Joint Tactical Radio System (JTRS) to a high of 254% for SBIRS. The

8 The "baseline" is the time-phased spending plan and associated events that are approved by the Milestone Decision Authority (MDA) at program inception – usually MS B.

aggregate total program cost growth is $99 billion (in constant FY2005 dollars). It is extremely important to note that this dollar figure is highly theoretical—it represents the *estimated* total investment costs over the entire life of the acquisition phase of the programs (including both future and sunk costs), *if* the current cost estimates prove accurate *and* currently projected procurement quantities are unchanged.

The 5000 series directives lay out a normal sequence of acquisition program phases, demarcated by major reviews (called Milestones) and other decision points. These are shown in a schematic outline in Figure 2, as they have evolved through various iterations of the 5000 series over the period reviewed in this study.

In all of these diagrams, the triangles indicate formal milestone reviews by the Defense Acquisition Board (DAB). The DAB is chaired by the Under Secretary of Defense (AT&L), acting in his capacity as the DAE. The vice Chairman of the Joint Chiefs of Staff (VCJCS) serves as vice chairman, while other principal members include the principal direct subordinates of the DAE, and the Director, PA&E (now CAPE), the Director, OT&E, the DoD Comptroller, representative of other concerned OSD staff elements, and the Secretaries of the Military Departments.

D. OVERVIEW OF THE DOD ACQUISITION PROCESS

This section briefly reviews the features of the DoD acquisition system that are directly relevant to the content of this report.

In addition to applicable law, DoD's acquisition process is governed by a linked set of directives, known collectively as the "5000 series." They were first approved in their current format in July 1971 and have evolved over the course of 12 generations.[9] The versions adopted in September 1987 departed substantially from previous versions' consonance with the recommendations of the 1986 Packard Commission report[10] and the Goldwater-Nichols Department of Defense Reorganization Act of 1986.[11] The principal recommendations of the Packard report can be succinctly characterized as "Do it right the

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9 The current DoD Directive 5000.01, dated November 20, 2007, is an updated version of an earlier version issued in May, 2003, with minor and administrative changes. The current DoD Instruction 5000.02 was issued December 8, 2008. The first 11 generations of the 5000 series are documented in "The Evolution of DoD Directive 5000.1 Acquisition Management Policy, 1971 to 2003," Acquisition History Project Working Paper #3, http://www.history.army.mil/acquisition/research/working3.html.

10 *A Quest for Excellence: Final Report to the President* by the President's Blue Ribbon Commission on Defense Management, June 1986.

11 http://www.ndu.edu/library/goldnich/goldnich.html.

first time" and "Do it within clear, short lines of decision authority." This basic approach was repeated with some variations in the versions issued in 1991 and 1996. Additional changes were made in 2000, and again in 2003. Since all of the decisions that are relevant to this study were taken under the 1991, 1996, 2000, or 2003 versions, we briefly review their main provisions as they apply to the programs we studied.

This report is concerned specifically with MDAPs, a category defined by law to include acquisition programs that are estimated to require an eventual total expenditure in Fiscal Year (FY) 2000 constant dollars of more than [12]

- $365 million in Research, Development, Test and Evaluation (RDT&E) *or*
- $2.19 billion in procurement.

All of the programs we studied exceeded the cost thresholds and have been designated as MDAPs. All MDAPs fall under Acquisition Category I (ACAT I).[13]

1. Acquisition Program Phases and Milestones

The 5000 series directives lay out a "normal" sequence of acquisition program phases, demarcated by major reviews (called Milestones) and other decision points. These are shown in a schematic outline in Figure 2, as they have evolved through various iterations of the 5000 series over the period reviewed in this study.

In all of these diagrams the triangles indicate formal milestone reviews by the Defense Acquisition Board (DAB). The DAB is chaired by the Under Secretary of Defense (AT&L), acting in his capacity as the DAE. The Vice Chairman of the Joint Chiefs of Staff (VCJCS) serves as vice chairman, while other principal members include the principal direct subordinates of the DAE, and the Director, PA&E (now CAPE), the Director, OT&E, the DoD Comptroller, representatives of other concerned OSD staff elements, and the Secretaries of the Military Departments.

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12 The relevant law is codified as 10 USC §2430. The base year is changed by DoD action from time to time, with amounts adjusted by the officially approved deflators, as provided by the law.

13 Acquisition categories are established by the 5000 series directives to facilitate decentralized decision making and execution and compliance with statutorily imposed requirements. The categories are determined largely by the cost level of the program, and determine the level of review, decision authority, and applicable procedures. There are currently four top-level categories with a variety of sub-categories and sub-sub-categories. Generally only ACAT ID is of concern in this study, although JASSM reverted to ACAT IC for several years.

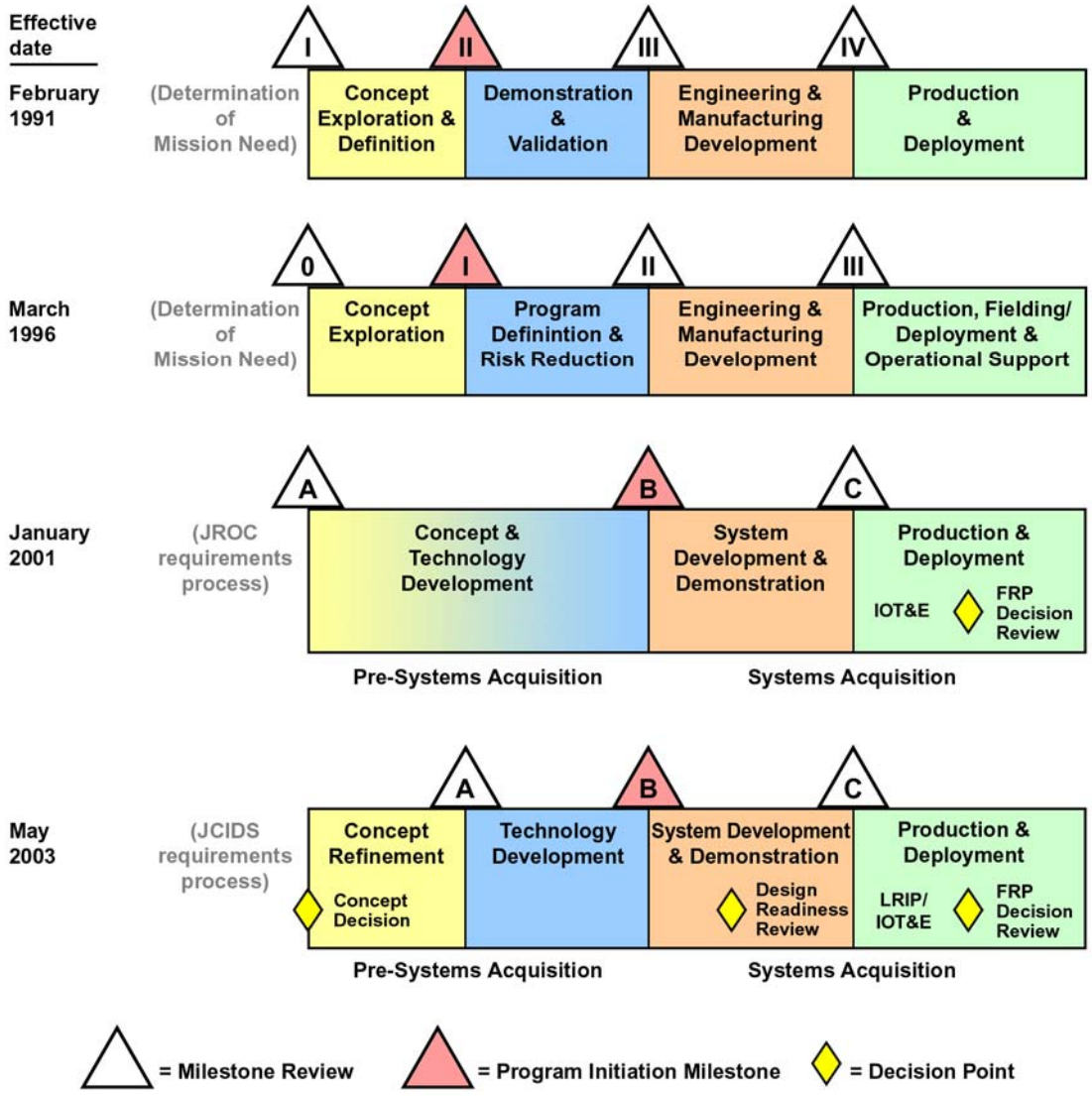

Figure 2. Acquisition Process as Defined in DoD 5000 Series Documents, 1991-2008

Although it has had no effect to date on any of the programs reviewed here, we will refer later to the version of the acquisition process laid out in the revision published in December, 2008, which is depicted in **Error! Reference source not found.**.

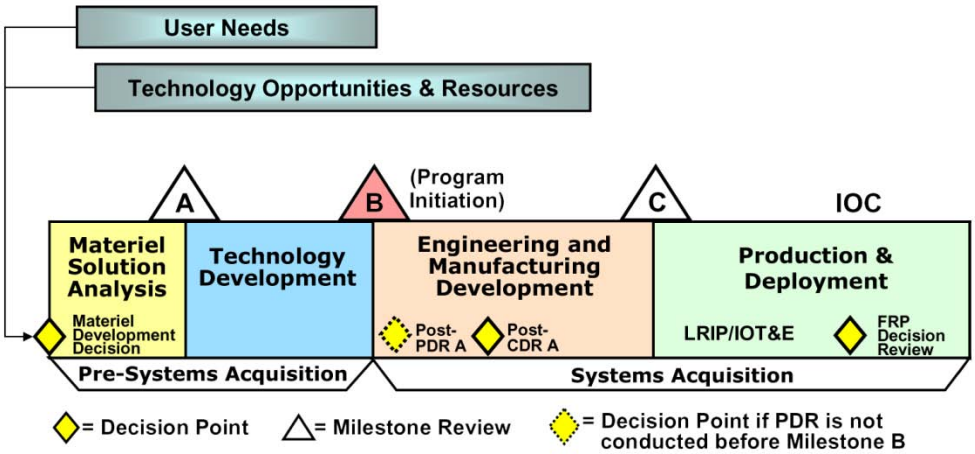

Figure 3. Acquisition Process as Revised by DoDI 5000.02, December 2008

2. Management Responsibilities and Processes

Each MDAP has a program manager (PM) who normally reports through a program executive officer (PEO) to a Service or Component acquisition executive (SAE or CAE) or Component head who, in turn, is responsible to the DAE.[14] The SAEs are assistant secretaries of the Military Departments. This structure resulted from the Packard Commission recommendation that the department strengthen Defense acquisition decision-making.

Programs must receive approval to proceed at each milestone from the Milestone Decision Authority (MDA). For ACAT I programs (i.e., MDAPs) the MDA is normally the DAE, in which case the program is ACAT ID. If he sees fit, the DAE may delegate milestone decision authority to a SAE/CAE, in which case it becomes an ACAT IC program. DAEs typically delegate milestone authority for major programs when the residual risk is assessed as minimal—for example, for follow-on production decisions.

A program becomes an acquisition "Program of Record" at the points shown in Figures 2 and 3--at Milestone II until 1996, at Milestone I from 1996 until 2000, and at Milestone B since 2000. For many programs, formal initiation came after several years of effort costing hundreds of millions of dollars in system concept and technology

14 This management structure was established by the Goldwater-Nichols Act.

development. In such cases, the developed concept usually has so much momentum (and support from vested interests) that it becomes difficult to cancel or redirect.

The 5000 series directives specify criteria that govern whether and when a program becomes ready for Milestone B review. The criteria have varied in detail over the years, but their most important (and durable) provisions require:

- A Component recommendation for a new program start, approved by the Joint Requirements Oversight Council (JROC) (see additional discussion below);
- Demonstrated readiness of the key component technologies of the proposed system to support full-scale/engineering and manufacturing development; and
- That the sponsoring Component demonstrate firm plans for funding the program within the Component's fiscal resources.[15]

In addition to these, the Acquisition Decision Memoranda (ADMs) for Milestone A (MS A) approvals (if held) have usually specified exit criteria that the program must meet before being considered for MS B approval.

3. Requirements, JROC, and JCIDS

Systems developed through the DoD acquisition process are intended to meet military needs, or "requirements." For the vast majority of MDAPs, these requirements are developed by the Military Services and reviewed by the JROC, which is chaired by the Vice Chairman of the Joint Staff. The Joint Capabilities Information and Development System (JCIDS) process was implemented to inform the process of JROC review. After its review, the JROC makes a recommendation, which is normally forwarded by the Chairman, Joint Chiefs of Staff, to the DAE. This requirements identification process, which was developed in response to the Goldwater-Nichols Act, was intended to reduce the dominance of the Military Services in determining what the Department should acquire and increase the emphasis on acquiring equipment to support joint operations. The process has been revised several times in efforts to better achieve those ends.[16]

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15 The mechanisms for doing that will be discussed later in this chapter and the next.

16 See Government Accountability Office, "DoD's Requirements Determination Process Has Not Been Effective in Prioritizing Joint Capabilities," GAO-08-1060, September 2008; interviews with former high officers and officials with direct knowledge.

Although Section 105 of the Weapon Systems Acquisition Reform Act of 2009 (WSARA 2009)[17] calls for stronger input to the JROC from the unified combatant commanders (CoComs), the CoComs are focused on operational near-term and often geographic-area-specific needs, so their inputs regarding longer-range acquisition programs are limited.

Although the Secretary of Defense clearly has the authority to adopt requirements other than those the Chairman recommends and could delegate that authority to the DAE, that authority is seldom exercised and has not been so delegated.

4. Analysis of Alternatives

The Analysis of Alternatives (AoAs) is the process of justifying that a proposed specific new acquisition program is the best solution for the need that has been identified. Strongly related to acquisition requirements, AoAs, according to DoDI 5000.02, must be completed before milestone A, B and C reviews (for the later milestones an update is required if a previous AoA was performed). The AoA is intended to evaluate the proposed program in comparison to alternatives, such as upgrades of existing systems, purchase of foreign or commercial systems, etc. The alternatives considered should be selected from a broad set for early AoAs and "necked down" for later ones. For example, for a mission for which a helicopter has been proposed, an AoA before MS A, might consider an unmanned air vehicle, whereas before MS B, only helicopter alternatives would likely be considered if the prior AoA had convincingly ruled out unmanned alternatives.

A recent GAO report evaluated a number of AoAs, including those for FCS and ARH, and found them wanting, as will be discussed in Chapter II and the appendixes. We did not, however, systematically review AoAs for this study --only when they came up in the context of cost growth.

5. Technology Readiness and Assessment

It is DoD policy that no system can enter full-scale development unless the technologies essential to its military effectiveness are mature enough to support the timely completion of development and system integration at an acceptable level of risk. Since the 1960s, DoD acquisition policy has emphasized the need for early technology

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[17] Public Law 111-23, May 22, 2009.

development and evaluation to reduce risks. As indicated in Figures 2 and 3, a formal technology development phase has long been the norm for MDAPs. By the late 1990s the need for a formal technology readiness assessment (TRA) process had become evident. The requirement for assessment of technology readiness became institutionalized in the October 2000 revision of the 5000 series.[18]

Today DoD has a formal system for grading technology readiness, expressed in terms of Technology Readiness Levels (TRLs) from TRL 1 (basic principles observed and reported) through TRL 9 (actual system proven through successful mission operations).[19] Over time, particularly since 2000, the governing TRL to be achieved before entry into full-scale engineering development has become more definitive, but the *actual* levels of technology readiness at Milestone B have varied substantially. The FY 2006 Defense authorization bill directed that TRL 6 be required unless a national security exception is granted by the DAE. The WSARA further definitized in law the need to assess technology readiness.

The process for assessing the soundness of the overall system concept, design, and integration plans is far less developed than that for technology readiness, and no formal mechanism to ensure that such plans are well-developed before approval to enter full-scale development currently exists.

6. Cost Estimating and the CAIG

The craft of cost estimation plays a central role in program planning in general, and acquisition program planning in particular. Until the late 1960s, the DoD process for estimating the cost of engineering and manufacturing projects began with analogies to earlier projects, scaled as necessary to account for increases in size and complexity. If the rough estimates seemed reasonable, and the project was judged to be a cost effective way to meet a real need, work proceeded on the design and planning until it was possible to list all of the required parts and materials together with the labor needed for manufacture and assembly. This provided the basis for a detailed "build-up" or "bottom-up" estimate

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18 DoD 5000.2-R, "Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs," 10 June 2001, section C7.5.

19 Defined in "Defense Acquisition Guidebook," <https://acc.dau.mil/dag>, Chapter 10, Table 10.5.2.T1, accessed 13 July 2009. Responsibility is assigned to the Director, Defense Research and Engineering, OUSD(AT&L).

of production costs. For a number of reasons, this approach did not work as well as expected.

For complex systems, such as aircraft and other weapon systems, the build-up approach requires a level of knowledge that rarely exists in the early stages of a system's detailed design. Furthermore, early experience with MDAPs showed that build-up estimates often were not reliable indicators of eventual actual costs. A refined version of costing by analogy was found to be superior. This involves a combination of engineering design reviews and statistical analysis of cost experience in other projects, known as *parametric cost estimation.* Parametric cost estimating of likely production costs is most reliable when it can draw on the widest possible base of accurate records of actual project costs. Parametric estimates for MS B reviews are made at the sub-system level, or even at the level of individual components, and then rolled up.

Vocal Congressional dissatisfaction with reported cost growth prompted then-Secretary Laird to establish the CAIG in 1972. In 1983, continuing Congressional concerns about acquisition cost estimation resulted in a requirement in statute[20] for the development of "Independent Cost Estimates" (ICEs) by an entity independent of the DoD Components responsible for developing the systems. The Secretary of Defense assigned that responsibility to the CAIG, but initially the CAIG was not adequately staffed to develop independent cost estimates for all of the programs the Department was initiating. The CAIG dealt with this problem by developing full-blown ICEs for only the most important programs, and reviewing and correcting Service-developed estimates for other programs—a course of action not entirely responsive to the statute.[21] A 1990 DoD Inspector General review, undertaken in response to continuing concerns about accuracy of acquisition program costing, resulted in a clear affirmation of the CAIG's responsibility to prepare independent estimates, and prompted a substantial increase in its staff.[22]

In the mid 1990s, OSD adopted the commercial business program management device of integrated product teams (IPTs) for overseeing acquisition programs.[23] This

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20 USC, Title 10, section 2434.

21 Donald Srull, ed., *The Cost Analysis Improvement Group, A History* (McLean, Virginia: Logistics Management Institute, 1998), pp. 32-33.

22 From about 10 people to about 30.

23 According to the Defense Acquisition University's *Glossary: Defense Acquisition Acronyms and Terms* (12th edition, July 2005), IPTs are "composed of representatives from appropriate functional

involved, *inter alia*, formation of cost IPTs to promote a free flow of information among the organizations involved in program costing and was intended to foster agreement on methodologies and data for developing cost estimates in support of acquisition milestone decisions.[24]

Data on cost growth in the pre-CAIG era are scanty and not of good quality, but available evidence indicates that the introduction of the CAIG and independent parametric cost estimates significantly and quickly improved the quality of costing and reduced cost growth.[25] Data from more recent experience have not yet been analyzed with comparable thoroughness, but there are indications that cost growth has increased in the past few years.

The parametric cost estimating process critically depends on the quality and breadth of the data about actual costs from which it can draw. For this reason, DoD requires submission of cost data in a form suitable for analysis, through the Cost and Software Data Reporting (CSDR) system, which is operated by the CAIG.[26] The accuracy of a parametric estimate of a system's cost depends on clear definition of the system's engineering and other characteristics. Estimates of development costs are inherently less accurate than estimates of production costs.

7. Roles in Preparing Cost Estimates

Program cost estimates are initially prepared by PMOs, assisted by Service cost centers and inputs from contractors. In preparation for Milestone B, the PM's cost estimate is reviewed by the Service cost analysis group, and after being modified in a give-and-take process, becomes the Service Cost Position (SCP). This estimate is then reviewed by the CAIG, which also normally develops an Independent Cost Estimate

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disciplines working together to build successful programs, identify and resolve issues, and make sound and timely recommendations to facilitate decision making. There are three types of IPTs: Overarching IPTs (OIPTs) that focus on strategic guidance, program assessment, and issue resolution; Working-level IPTs (WIPTs) that identify and resolve program issues, determine program status, and seek opportunities for acquisition reform; and Program-level IPTs (PIPTs) that focus on program execution and may include representatives from both government and industry after contract award."

24 Donald Srull, ed., *The Cost Analysis Improvement Group, A History*, pp. 41-43.

25 Neil M. Singer, "Cost Growth in Weapon Systems: Recent Experience and Possible Remedies," Congressional Budget Office, October 12, 1982, pp. 2-3; Defense Science Board, "Report of the Acquisition Cycle Task Force," 1977 Summer Study, 15 March 1978, pp. 68-9. See also David L. McNicol, et al., "The Accuracy of Independent Estimates of the Procurement Costs of Major Systems," Institute for Defense Analyses, IDA Paper P-3989, August 2005.

26 CAIG, "Cost and Software Data Reporting (CSDR) Manual," DoD 5000.04-M-1, April 18, 2007.

(ICE).[27] This process was put in place many years ago because it was clear that reasonable accuracy in the cost estimate was essential to a sound decision on the cost-effectiveness of the proposed program and whether to proceed. Independence was considered the key to minimizing the Service's tendency to "buy in" by underestimating the likely cost.

Currently it is DoD policy to fund programs to the independent CAIG estimates (which are generally higher than the service estimates) unless the MDA decides otherwise. That policy has not been consistently applied. An argument frequently made against funding to a higher CAIG estimate is that the higher estimate will become a self-fulfilling prophesy—that it is better to "hold the program manager's feet to the fire" to manage his/her program within the SCP estimate. There is, however, little if any empirical evidence to support that view,[28] and PMs can be incentivized through other means to pursue the lower cost goal. Another argument that is made from time to time is that "this program is different;" e.g., "We have an innovative new manufacturing process that obviates the historical data on which parametric production cost estimates are made." Milestone Decision Authorities have often been persuaded by one or more such arguments and have approved acquisition baselines less costly than recommended by the CAIG.

Studies have consistently shown that production costs for a substantial majority of acquisition programs come in within 30% of the estimates made at Milestone B (or Milestone II), after allowances are made for unforeseen inflation, quantity changes, and other deliberate program changes. In this group, positive and negative variances from the estimate are roughly equally distributed. But the minority of programs that have production cost growth of more than 30% contribute disproportionately to overall cost growth.[29] Most of the programs studied here fall or are projected to fall into the latter category.

On the whole, growth in development costs is proportionately greater than in production costs, as might be expected, given the greater uncertainties in the "invention"

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27 Time and resources permitting. One limitation on the CAIG review process is late submission of the SCP and the accompanying Cost Analysis Requirements Description (CARD), which is supposed to be submitted 180 days prior to the milestone decision DAB.

28 McNicol, et al., "The Accuracy of Independent Estimates," IDA Paper P-3989, pp. 11-13.

29 For a particularly comprehensive analysis see David L. McNicol, "Cost Growth in Major Weapon Procurement Programs," Institute for Defense Analyses, IDA Paper P-3832, October 2004, pp. 18-19.

phase.[30] However, the overall impact on total program costs is usually less because RDT&E constitutes a smaller fraction of total program cost than procurement.

8. Acquisition Program Baselines

Acquisition Program Baselines (APBs) are a legal requirement for MDAPs and must be approved by the MDA.[31] The PM develops a draft APB that sets the overall goals of the program including specific targets for *performance, cost, and schedule*, generally with both objective values and thresholds of acceptability. The initial APB must be prepared for approval at program initiation – generally the normal program initiation milestone shown in Figures 2 and 3, although some programs do not begin or become formally recognized until a later stage in the process. New APBs are required at the beginning of each succeeding phase. The PM is required to report any breach of an APB threshold to the MDA, and to provide plans for recovery and recommendations for action. Normally this process results in a revision to the APB to reflect the new plan. Problems with the APB process, and its associated Acquisition Strategy Reports, are discussed at some length in Chapter II.

9. Affordability

The decision to start an acquisition program should be made with confidence that the resources to complete the acquisition will be available. Financial resources are allocated through the DoD Planning, Programming, Budgeting, and Execution System (PPBES), one component of which is the Department's Future Years Defense Program, or FYDP. In order to enter EMD at MS B, DoDI 5000.02[32] requires that the program be fully funded, as reflected in the APB, in the sponsoring Component's Program Objective Memorandum [33] (POM) and ultimately in the FYDP. (Problems with the mapping APBs to the FYDP and budget, are discussed in Chapter II.)

The FYDP, however, only contains information for five years beyond the budget year. Since most MDAPs require investment funding well beyond that time period, an

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30 Ibid., p. 17.

31 10 USC §2435.

32 DoDI 5000.02, Enclosure 2, Engineering and Manufacturing Development (EMD) Phase, sec. d (4), (December 8, 2008), p.23.

33 Program Objective Memoranda are developed biennially by each DoD Component and submitted to the Secretary for approval. They form the basis for DoD's next budget and the FYDP, which is the mid-term financial plan.

important issue is whether sufficient resources to complete the program will likely be available in the years beyond the FYDP—that is, whether it will be affordable in the longer term. A declaration of affordability must meet three conditions: (1) that the cost of the program be known within a reasonable level of certainty (say, within 15%); (2) that demands for funds for other acquisition programs also be reasonably well-defined; and (3) that the resulting total acquisition costs do not result in an unbalanced distribution of funds among the manpower, operating, and acquisition accounts.

The Defense Program Projection (DPP) is a process that periodically examines such longer term programmatic issues. It is based on approved acquisition and major force programs, service long-range plans, and logical extensions of acquisition programs that are started within the FYDP.[34] It provides the primary context for addressing longer-term acquisition affordability issues.[35] It is, however, seldom used in the acquisition process, as best we were able to determine. To the extent that affordability assessments for the 11 programs were formally conducted, they considered only whether the required funds would be available in the FYDP.

E. DATA SOURCES AND THEIR QUALITY

1. Selected Acquisition Reports

Selected Acquisition Reports (SARs) were initiated by OSD in the mid-1960s to provide basic information to DoD management on the status of the most important acquisition programs. Since 1969, Congress has required that the SARs for MDAPs be submitted to the Congressional defense committees within 60 days of submission of the President's Budget. The SARs include the following major sections:

- *Program information*:
  - *Responsible Office*: Contact information for the program manager and Program Executive Officer (PEO)
  - *Mission and Description*: An overall description of the system and its mission

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34 The usual assumption is that total DoD funding will be constant in real dollars beyond the FYDP.

35 The DPP analysis, conducted by OSD(PA&E) with the cooperation of the Services, other DoD Components, and staff, is periodically briefed to senior DoD leadership, but is closely held. It is not a formal part of the DoD PPBES process, and it is not approved by the Secretary. When the DPP was initiated in the early 1990s, the AT&L staff participated in its development; however, over time, AT&L active participation ceased.

- *Executive Summary*: An overview of current status by the program manager

- *Threshold Breaches*: Reports any breaches to schedule, performance or cost thresholds and gives reasons
- *Schedule and Performance:* Objectives, including "objective" and threshold" values for schedule and performance (each a separate section)
- *Track to budget*: Specifies what Program Elements in the DoD budget contain the funding for the program
- *Cost and Funding*:
  - A Summary showing total acquisition costs (RDT&E, Procurement, and Military Construction) and production quantities, and
  - Annual Funding, which displays RDT&E and procurement costs (by budget appropriation) and procurement quantities by year. (Costs are given in both a base-year constant dollars and inflated ("then-year") dollars.)
- *Unit Cost Report*: Described in more detail below
- *Cost Variance*: Tracks the differences in costs, with a table comparing the current estimate to the "baseline" estimate by "reason" for the cost changes, followed by explanations of the "reasons"
- *Contracts:* Provides names and addresses of contractors and dates of contracts, contract costs, (initial, current, and estimate at completion), and cost and schedule variances
- *Deliveries and Expenditures*: Gives production deliveries and funds expended
- *Operating and Support Costs*: Provides estimates of the costs to operate and support the system after fielding and compares those costs to a comparable existing system (if applicable).

Most of these sections are required by law in 10 USC Section 2432. In essence, the SAR is a periodic report on the progress of the program, with the greatest emphasis on unit cost measures. The comprehensive history of SAR cost data since 1970 constitutes the primary data base generally used for studies of cost growth. Although the SAR data base suffers from significant limitations for that purpose, there are no good alternatives.[36] Because the SARs are so important to Congress, DoD goes to greater

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[36] Paul G. Hough, "Pitfalls in Calculating Cost Growth from Selected Acquisition Reports," The RAND Corporation, N-3136-AF, 1992.

lengths to ensure their accuracy than it does in maintaining comprehensive internal records of MDAP progress, at least at the OSD level. This study, therefore, largely relied on SAR data for its cost growth estimates.

2. Defense Acquisition Executive Summaries

The office of the USD(AT&L) established the Defense Acquisition Executive Summary (DAES) system to meet its own need for information. For the most part, the DAES reports contain the same information as SARs but they are updated more frequently. The only substantive addition in the DAES is an "Assessments" section provided by the sponsoring Component (in essence, the PM) with stoplight charts for "cost, schedule, performance, funding and sustainment" versus the APB and "contracts," together with an "Explanations" section. This is followed by a section entitled "OSD Assessments" for the same topics. In our review of the data for the 11 programs selected for this study, only occasionally did we find the OSD assessments section to contain *any* information.

Originally, DAES reports were submitted quarterly, but since the advent of a web-based acquisition data collection system, the DAES reports are supposed to be updated by the Program Management Offices (PMOs) with the latest available program information, once it becomes "official." Our study did not include a formal review of the extent to which such updates are being provided.

3. Defense Acquisition Management Information Retrieval System

The Defense Acquisition Management Information Retrieval (DAMIR) system is an internal DoD web-based repository of SAR and DAES reports, with historical documents going back a number of years. The following description is from the website:[37]

> **DAMIR** is a DoD initiative that provides enterprise visibility to Acquisition program information. The primary goal of DAMIR is to streamline acquisition management and oversight by leveraging the capabilities of a net-centric environment. DAMIR identifies various data sources that the Acquisition community uses to manage Major Defense Acquisition Programs (MDAPs) and Major Automated Information Systems (MAIS) programs and provides a unified web-based interface through which to present that information. DAMIR enables the OSD, Military Services, Congress and other participating communities to access information relevant to their missions regardless of the agency or where

[37] http://www.acq.osd.mil/damir/

the data resides. DAMIR components have replaced the need for the legacy Consolidated Acquisition Reporting System (CARS).[38]

One component of DAMIR, **Purview**, is an executive information system that displays program information such as mission and description, cost, funding and schedule. It was developed under the DAMIR initiative to provide a comprehensive view of the current state of all MDAP and MAIS programs. It is OSD's solution for structured acquisition data presentation and uses web services to obtain and display Defense Acquisition Executive Summary (DAES) data directly from the Service acquisition databases. Within Purview users can also execute Ad-hoc reports. In addition, select DAMIR users can create, edit, or review the following: Selected Acquisition Reports (SARs), SAR Baselines, Acquisition Proposed Baselines (APBs), and Assessments.

DAES information is obtained through use of web services connected to Service acquisition information systems. Some insights from our use of DAMIR are included in the next chapter.

4. Earned Value Management System

The Earned Value Management System (EVMS) was established in 1967 as the Cost/Schedule Control System (C/SCS or $(CS)^2$) to track "earned value" (EV) – the *value* of the work done on an acquisition contract relative to the required end product – against actual and planned expenditures. If expenditures are outrunning EV, it is clear sign of program trouble, and the degree of divergence is an indicator of the probable extent of ultimate cost growth. Over the past three decades the responsibility for the system shifted from the DoD Comptroller to the USD(AT&L) and finally to the Defense Contracts Management Agency (DCMA).[39] Accurate EVMS data, properly interpreted, provides valuable insights into program status.

5. Nunn-McCurdy Breaches and Unit Cost Reports

The law requires that Congress receive "unit cost reports" in the event that certain thresholds of cost are breached.[40] These are generally known as "Nunn-McCurdy

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38 DAMIR has a multi-level access capability; for example, DAES reports are only visible by DoD personnel, and some portions are only visible by users explicitly approved by OUSD(AT&L).

39 Government Accountability Office, "Significant Changes Underway in DOD's Earned Value Management Process," GAO /NSIAD-97-108, May 1997.

40 10 USC §2433.

breaches," after the sponsors of the original 1982 law (which has been much amended). The cost-growth thresholds that trigger such reports are shown in Table 2.[41]

Table 2. Nunn-McCurdy PAUC Reporting Thresholds

	Significant Breach	*Critical* Breach
From current baseline	+15%	+25%
From original baseline	+30%	+50%

Each Nunn-McCurdy breach requires specific DoD management and reporting actions. At the end of the quarter following any breach, a complete SAR must be submitted, with an explanation of the reasons for the cost growth.

In addition, when the breach is "critical," the USD(AT&L) must certify that:

1. The program is essential to the national security,
2. There is no alternative that will provide equal or greater capability at a lower cost,
3. The new cost estimates are reasonable, and
4. The management structure is adequate to control cost growth.

Under the law, the authority to obligate funds for the program lapses if no certification is provided. In the case of one of the programs we studied, the Armed Reconnaissance Helicopter, the USD(AT&L) determined that he could not make such a certification and terminated the program.

When a program is certified following a critical Nunn-McCurdy breach, a new APB is required, an action known as re-baselining. Re-baselining also occurs at each subsequent milestone review. Notwithstanding the establishment of a new "current baseline," the values set out in the Milestone B APB must continue to be reported as the "initial baseline." The complete baseline history is contained in a document available on DAMIR for MDAPs past Milestone B/II.

The Nunn-McCurdy breach reports have proven very valuable in this study for understanding the causes of cost growth.

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41 The law sets identical thresholds for growth in Average Procurement Unit Cost (APUC), which is obtained by dividing total procurement costs by the total number of units procured.

II. FINDINGS AND CONCLUSIONS

In this section of the report, we present our principal findings and conclusions regarding the causes of cost growth in the 11 programs examined. The chapter begins by dividing the major causes of cost growth into two major categories, which are then sub-divided into additional categories. Subsections of the chapter provide explanation and evidence from the programs examined to support the findings. Finally, we identify three lesser causes, which are presented and explained in subsequent subsections. Appendices for each of the 11 programs present its history and explore in greater depth the reasons for its cost growth. While some of that material has been brought into this chapter to support our findings, brevity dictated that much was not used, so the reader, if privy to FOUO material, is encouraged to explore the appendices in Volume 3 for additional important insights.

A caveat: Our findings are based on the examination of the 11 programs which, as was stressed Chapter I, were selected because of their significant cost growth. We did not examine the many successful DoD acquisition programs that did not have large cost growth. But even if these findings and conclusions were found to apply exclusively to the 11 programs (an extremely unlikely premise), they deserve serious consideration because of the importance of those particular programs.

Avoiding cost growth is not just a narrowly technical matter of having the right organizational structure staffed by capable professionals using sound policies and procedures. Indeed, generally sound policies and procedures have long been in place. Decisions on starting a new major defense acquisition program involve making choices on critically important matters of national security and huge expenditures of resources. Accordingly, the key decisions on MDAPs are made by politically accountable officials. Good outcomes require that those officials be given an accurate assessment of the decisions to be made and sound advice on the consequences of various alternatives. There is, however, also a legitimate policy dimension to their decisions in that the top officials of DoD decide, explicitly or implicitly, how much risk should be borne in acquisition programs, and those choices in turn have an important influence on subsequent cost growth.

A. OVERVIEW OF COST GROWTH MAJOR CAUSES

Figure 4 summarizes the major causes we identified through our analysis of growth in our sample of high-growth MDAPs.

1. Weaknesses in management visibility, direction, and oversight

a. Lax or inappropriate implementation of policies

b. Excessive reliance on unproven management theories and acquisition strategies

c. Poor contractor selection, oversight, and incentivization

2. Weaknesses in initial program definition and costing

a. Defective and unstable requirements processes

b. Entry into development with immature technologies

c. Deficient front-end analysis of system-level design issues and technical risks

d. Excessive schedule compression and concurrency

Figure 4. Major Causes of Acquisition Cost Growth

As will be seen, no single major cause explains cost growth for the majority of the programs. The causes listed in Figure 4 are not mutually exclusive. Many are closely interrelated, and there are compounding effects in which the various causes of cost growth interact and reinforce each other. For example, when a program receives approval to enter development, despite being so ill-defined and technically immature that its costs cannot be estimated with even rough confidence, it presents *prima facie* evidence not only of weaknesses in management oversight, including lax implementation of policies, but also in program definition and costing. For this reason, we cannot assign specific percentages of cost growth to individual causes. Nevertheless, our analysis indicates that, while the causes manifest themselves in different ways from program to program, there are important commonalities. And when taken together, these factors tend to dominate, forming the basis for the recommendations presented in the next chapter.

Table 3 documents the cost growth in the 11 programs from the initial APB through each re-baselining to the current estimate as reflected in the latest DAES report.

Table 3. Cost History of Programs Examined

		APB estimate at MS-B	*First re-baselining*	*Date*	*Second re-baselining*	*Date*	*Third re-baselining*	*Date*	*Current Estimate*
ARH	RDT&E($B)	0.38	0.70						0.94
Note 1	Procurement($B)	2.79	4.60						6.3
	PAUC ($M)	8.6	10.3						14.15
	APUC($M)	7.6	9.0						12.31
	Qty	*368*	*512*						512
FCS	RDT&E($B)	18.0	26.44	Nov-05					27.0
	Procurement($B)	59.1	92.79						98.4
	PAUC ($M)								
	APUC($M)								
WIN-T	RDT&E($B)	0.71	1.40	Jun-07					
	Procurement($B)	9.15	11.72						
	PAUC ($M)	9.9	13.1		17.2	*Note 2*			
	APUC($M)	9.2	11.7						
JTRS-GMR	RDT&E($B)	0.85	1.21	Jan-08					1.43
	Procurement($B)	13.59	13.06						12.27
	PAUC ($M)	0.133	0.165						0.158
	APUC($M)	0.126	0.151						0.142
	Qty	*108086*	86652						*86652*
Global Hawk	RDT&E($B)	0.84	2.09	Mar-02	2.17	Dec-02	3.08	Sep-07	3.00
	Procurement($B)	3.48	3.76		2.91		4.91		5.09
	PAUC ($M)	69.0	117		102		150		151.6
	APUC($M)	55.0	74		57		91		94.3
	Qty	*63*	51		51		54		*77*
JSF	RDT&E($B)	32.3	42.1	Mar-04	42.1	Mar-07			40.2
	Procurement($B)	143.3	149.5		169.0				169.4
	PAUC ($M)	61.8	78.6		86.5				85.5
	APUC($M)	50.2	61.2		69.2				69.3
	Qty	*2842*	2443		2443				*2443*
JASSM	RDT&E($B)	0.77	0.89	Dec-01	1.07	Dec-02	1.10	Mar-04	1.15
	Procurement($B)	0.96	1.62		1.87		2.90		4.06
	PAUC ($M)	0.709	0.669		0.779		0.737		1.16
	APUC($M)	0.400	0.439		0.509		0.542		0.686
	Qty	*2400*	3700		3700		5353		*5353*
LPD-17	RDT&E($B)	0.08	0.09	May-97	0.11	Oct-05	0.11	May-07	0.12
	Procurement($B)	8.94	8.93		12.84		10.99		14.37
	PAUC ($M)	751.6	751.6		1079.6		1079.6		1316.5
	APUC($M)	743.8	743.8		1070.2		1070.2		1305.9
	Qty	*12*	*12*		*12*		*9*		*10*
LCS	RDT&E($B)	1.19	2.23						2.95
Note 3	Procurement($B)								
	PAUC ($M)								
	APUC($M)								
EFV	RDT&E($B)	1.53	1.78	Nov-02	2.46	Mar-05	3.48	Aug-07	3.83
	Procurement($B)	6.82	7.35		8.92		9.62		10.58
	PAUC ($M)	8.2	8.9		11.1		22.2		17.5
	APUC($M)	6.7	7.3		8.8		16.8		17.3
	Qty	*1025*	*1025*		*1025*		*593*		*574*
SBIRS	RDT&E($B)	3.33	3.02	Mar-98	5.43	Sep-02	7.02	Mar-06	7.43
	Procurement($B)		0.50		1.26		1.34		2.20
	PAUC ($M)	694	736		1468		2856		2455
	APUC($M)		248		421		1343		1100
	Qty	5	5		5		5		4

Note 1: Not rebaselined. First "rebaselining" entry reflects Sep-07 SAR. "Current estimate" values are those estimated by CAIG at the Nunn-McCurdy Breach
Note 2: Estimate at the Nunn-McCurdy Breach
Note 3: LCS costs are based on President's Budget (PBP data, not SARs, since the SARs costs do not include all sub-systems.) The three costs are from the FY 2004, FY 2008, and FY 2009 PBs respectively.

1. Weaknesses in Management Visibility, Direction, and Oversight

This broad category focuses on a general lack of discipline and attention to detail among the offices that have been responsible for overseeing MDAPs in recent years. Evidence of this general lack of attention includes the decline in the documentation of independent program assessments in the DAES. The DAES process was originally intended to provide the DAE with timely warning of problems, based, in part, on systematic evaluations of earned value. Other evidence of weakness includes the uneven quality of the directions provided in Acquisition Decision Memoranda and their associated Acquisition Strategy Reports, as well as the lack of a system for tracking compliance with the DAE's decisions, including the tracking of funding decisions into subsequent DoD budget requests. One result of this general lack of discipline was that problems in some programs festered for years with no formal DAE review until legal thresholds were breached.

On the other hand, several of the programs received quite a lot of management attention (e.g., FCS, Global Hawk, JSF, JTRS-Ground Mobile Radio (GMR), and SBIRS), but top-level guidance did not prove effective in getting troubled programs on track. FCS and Global Hawk, despite annual DAB reviews, continued to have major problems. The reasons for these shortfalls are complex, and much of the fault probably lies within the DoD culture of optimism. When a large-scale program gets off to a bad start or heads off in the wrong direction, it is very difficult, for cultural reasons, for a DAE to take the kind of strong action, such as major program restructuring or cancellation that may be required.[42]

Even when major restructuring is undertaken, it will not be effective if the fundamental problem is not addressed. A case in point is JTRS-GMR. In 2006, the DAE directed a major restructuring of the program, but failed to address the underlying issue that the technology was simply not mature enough to accomplish the program's objectives.

One cause of poor decision-making is the lack of good information. The next two sub-sections address our finding that in the last few years there has been a deterioration in the systems that provide information on programs to top acquisition leadership. Except for certain high visibility programs, the DAE does not routinely review programs that do

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[42] These complex reasons are beyond the scope of this study.

not appear to be in trouble. But as noted, the systems for revealing timely evidence that programs are in trouble have been working badly. When we asked people who had served as DAEs during periods when signs of trouble were emerging in specific MDAPs whether they could recall having been alerted to them their answers were largely negative.

The Defense Acquisition Executive Summary

As discussed in the introduction, the DAES system was put in place two decades ago to provide periodic visibility into a program's progress and a timely warning of developing problems. In theory, every active MDAP is considered for review once a quarter. Among the score or more of programs up for review each month,[43] a few are selected by the AT&L OSD staff—sometimes over Service objections – for discussion at a DAES meeting—at least nominally with the DAE. Unfortunately, this system has become ineffective in recent years. In the early 2000s, responsibility for the DAES was moved from a directorate that has historically taken a relatively objective view of programs to a directorate that is more closely associated with program proponency. Moreover, some recent senior executives have not seen the value in the process, have not attended the monthly meetings, and have not encouraged the AT&L staff (aided by the rest of the OSD staff and Joint Staff)[44] to bring forth potential problems for review.

As previously mentioned, the DAMIR system, the repository for both SAR and OSD DAES reports, is linked to Component acquisition information systems in order to provide timely updates of program information. But like any system, DAMIR is only useful if the data are current and used for analysis. Unfortunately, component program managers have little incentive to reveal problems when they first threaten to arise since it is human nature is to wait and see if the problem can be solved without the attention of higher echelons (a "strategy of hope"). Our review indicated that periodic OSD assessments have only infrequently been conducted and included in the DAMIR in recent years. Thus, emerging problems appear to have rarely been identified to the DAE via the DAMIR system.

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43 There are approximately 100 MDAP and pre-MDAP programs that are subject to review. (Pre-MDAPs are programs that will likely qualify as MDAPs once they pass MS B.)

44 OSD staff elements such as CAIG, Director, Operational Test & Evaluation (OT&E), and AT&L Systems and Software Engineering frequently learn of difficulties in programs through their own channels of information. If incorporated into DAES, these inputs could provide valuable and timely information to the DAE on emerging problems.

Recently Congress has recognized the need for improved independent assessments of the status of major acquisition programs and has included a requirement for a new Performance Assessment and Root Cause Analysis (PARCA) process in the WSARA.[45] It is expected that the office assigned responsibility for PARCA will establish a review process that either revitalizes or replaces the somewhat dysfunctional DAES.

There are several elements of a "proper" periodic review of program status. These include the achievement of specific contract and APB/ASR/ADM milestones, such as first test article delivery and a host of more detailed milestones set forth in approved program plans. Such reviews would require the OSD PARCA staff to systematically track actuals against such plans including promises made at the time of program initiation or at subsequent reviews. The lack of an OSD system for independently tracking such plans and promises is addressed in our recommendations chapter.

EVMS and CSDR

In addition to tracking programs against discrete milestones, the oversight function is intended to benefit from the EVMS. The primary purpose of the EVMS is to help program managers track their own progress against their own plans as reflected in the work breakdown structures in their cost-type contracts. EVMS, together with the CSDR system, were also intended to provide valuable information to senior management. In practice, those systems frequently lack rigor and fail to provide the insight into actual program progress that they could.

In the case of ARH, clear warning signs in the EVMS that a massive contract cost overrun was in train were ignored—reportedly because "everyone knew Bell Helicopter's EVMS was defective." (It had in fact been de-certified.) Nonetheless, in this case the EVMS's indications of a serious cost overrun were accurate. As part of streamlining efforts under acquisition reform, contractors were sometimes allowed to report cost and schedule performance in their own formats. Such was the case with JASSM and SBIRS. The result for JASSM rendered EVMS "not reliable for management use," according to the Nunn-McCurdy certification assessment by DCMA, while a "leaned-out" program office failed to take notice. Those practices have often impeded visibility into developing problems, as they did in SBIRS and JASSM.

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[45] Weapons Systems Acquisition Reform Act of 2009, Section 103.

ADMs and other DAE memoranda frequently contain specific direction for program content, often intended to help contain costs. Since there is no system to track whether or how well such direction is carried out, we were unable to determine whether failure to execute DAE direction contributed to cost growth.

Other Evidence of Top-Level Oversight Weaknesses

As we have already noted, the early signs of trouble in the ARH revealed by the EVMS were not heeded. And four and a half years elapsed between ADMs for the LCS, during which both schedule and cost grew by more than 100%. JASSM was re-designated as ACAT 1C for Air Force oversight after completion of development, in the name of acquisition reform and streamlining. Over the next five years serious reliability problems emerged. Average Procurement Unit Cost (APUC) grew by more than 45%, the program was expanded to include a new, more expensive extended range variant, and planned procurement quantity doubled without JROC approval. We did not find any evidence that these issues received any serious attention from the OUSD(AT&L) until recurring missile reliability problems resulted in cost growth, and a critical Nunn-McCurdy breach.

a. Lax or Inappropriate Implementation of Policies

Over the years the Department has accumulated a great deal of experience on how to establish and manage sound major acquisition programs. These "lessons learned" track back to and before the 1986 Packard Commission report[46] and are well codified in standing DoD policies and procedures. They can be summarized as "Do it right the first time." These "standing orders" intentionally provide enough flexibility to allow each unique program to be sensibly structured and managed without imposing an inefficient straightjacket. One way to interpret the findings in this report is to observe that many of the problems it identifies can be attributed to excessive use of that flexibility. Indeed, it is common for outside critics of defense acquisition practices to say in effect "These problems wouldn't have happened, or wouldn't have been so serious, if the Department had only followed its own policies."

More specifically, we identified several standing policies whose neglect contributed seriously and directly to the problems encountered by several of these

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46 *A Quest for Excellence: Final Report to the President* by the President's Blue Ribbon Commission on Defense Management, June 1986.

MDAPs. Two of those policies were of key importance: (1) ensuring that the requirements for a new acquisition program are well-understood and firm; and (2) ensuring that technologies critical to successful full-scale development and production of the system are sufficiently mature. Both those issues plagued many of the programs we examined, and will be discussed in more detail in subsequent sections of this chapter.

Most existing policies governing MDAPs were adopted in response to lessons learned from program failures, with the implication that adherence to them is necessary to avoid repetition of such failures. Nevertheless, DoD has repeatedly waived or ignored the application of policies, or relaxed policies without analysis of the implications.

New Program Starts

The Introduction reviewed the history of DoD's search for the right way to start acquisition programs. Responding to the reality that, at least in some circumstances, it is not necessary to "start from scratch," DoD implemented more flexible options for starting programs in the 2003 version of DoDI 5000.2.[47] Programs were allowed to come to the DAB for approval to enter formal MDAP status directly at MS B or even Milestone C, thus bypassing the earlier decision points. Out of the eleven MDAPs in our sample, five did not have MS A reviews, but the justifications for failing to do so now appear dubious. In the case of Global Hawk, one might argue that bypassing MS A was justified because the program was a transition from a DARPA[48] Advanced Concept Technology Demonstration (ACTD) program, which includes some of the features of a Technology Development phase. However, we were informed by knowledgeable people that in fact the ACTD aircraft was not ready for full-scale development and significantly deficient in systems design and engineering. Problems traceable to that poor start have plagued the program ever since. Almost all of the 11 programs suffered serious problems that relate to the lack of front-end review and adequate technology development.

The FCS program is another salient example. The program was initiated by fiat from the Chief of Staff of the Army, who was reacting, in part, to the difficulties the

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47 This change in policy entailed risks: acquisition programs are supposed to be initiated in response to needs to provide military capabilities to enable accomplishment of national security goals and objectives, as codified in the President's National Security Strategy and the Secretary of Defense's National Defense Strategy. The "front end" of the acquisition process is supposed to ensure this aim. Thus, to short-change the front end is to risk that a program being initiated is in fact *not* consistent with priorities expressed or implied by those basic documents.

48 Defense Advanced Research Projects Agency.

Army experienced in deploying a heavy combat brigade from Germany to Kosovo in 1999. Without evidence of in-depth supporting analysis, the Chief concluded that the Army needed to build a much lighter force that would still be capable of defeating traditional heavy forces through the use of superior battlefield knowledge. He requested that DARPA undertake development of several of the key technologies needed to implement the concept. In 2002, shortly before his retirement, the Chief of Staff directed the Army to take the program to the DAB for a MS B decision, and that review was held in May 2003. There was no MS A or earlier USD (AT&L) approval process for this massive new program

The omission of MS A was particularly damaging because of the world situation at the time. The terrorist attacks of September 11, 2001 and ensuing events had fundamentally changed the national security environment and thus national defense priorities. Was a multi-billion dollar program to achieve a quantum improvement in the capabilities of Army heavy forces for conventional warfare consistent with the capabilities the future Army would need? We found no evidence that this key question was asked.[49] And given the high level of technical risk and uncertainty with the attendant cost risk, would the Army be able to afford the program in the long run without detracting from capabilities the Army would need to fight the global "war on terrorism?" Again, apparently these questions were not asked, or if asked, they were not given sufficiently serious consideration.

Even if a program initially passes the test of consistency with national defense priorities, the question must be re-examined throughout the life of the program because major acquisition programs tend to stretch over many years, during which national security objectives can change. That is precisely what happened for several of the programs that we examined, including the expeditionary fighting vehicle (EFV), LPD-17 and, less clearly, the short takeoff/vertical landing (STOVL) capability for JSF. The continuation of these programs can be questioned on the basis that opposed amphibious assaults have considerably less utility in the post-9/11 national security environment. Inclusion of the STOVL requirement for JSF for the United Stated Marine Corps

[49] We realize, of course, that it is possible that the question could have been raised without leaving discoverable evidence.

(USMC), which had (and is having) a major impact on the cost growth in the program, was decided without apparent serious consideration of this issue.[50]

SBIRS also avoided MS A examination (or Milestone I, as it then was). There had been prior attempts to initiate programs to fill the same global infrared surveillance need which had foundered on the same requirements and cost issues that have so troubled SBIRS, and it is clear that evading consideration of these issues at a MS A review was not sound.

Neither WIN-T nor JTRS-GMR had a MS A review. We have not uncovered the reasons why, other than a general belief that commercial communications technology was well advanced and applicable to these needs, but we found no evidence that the MS A question was ever explicitly considered. The state of technology readiness clearly did not support entry into System Development and Demonstration (SDD) (see next section). An MS A review is exactly what should have transpired, in lieu of an MS B. It would have been a forum for closer examination of what proved to be a deeply flawed and fundamental assumption.

b. Excessive Reliance on Unproven Management Theories and Acquisition Strategies

Most of these troubled programs had been subjected in one way or another to various "acquisition reform" initiatives that have a long and somewhat checkered history since their high point as key elements of the Clinton Administration's "Reinventing Government" initiative. In the early 2000s, "acquisition transformation" was part of the overall business transformation initiative.

Many of those initiatives grew out of perceptions in industry and some business schools that the Department was needlessly slowing acquisition programs and driving up costs by imposing excessive specifications, compliance rules, and testing requirements. If only DoD would acquire new weapons systems more like the private sector, the theory went, then new equipment would get into operational inventories faster and at lower cost to the taxpayer. Usually overlooked in such exhortations was the fact that the private sector has very little experience in developing systems as large, complex, or technologically challenging as the typical MDAP. When technically complex and

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[50] Another consideration with regard to STOVL was the United Kingdom requirement for a Harrier replacement. According to one senior official that consideration was actually the driver.

challenging commercial systems are developed, it is almost always "in house," with the details concealed from public view. Such work generally constitutes the core competence of big industrial companies and is not "outsourced" under contracts to outside companies as are DoD MDAPs. The Boeing 787 "Dreamliner" is unusual in that its internal troubles have come at least partly into public view, but in fact such cost growth and delays are common in highly complex private sector programs, just as they are in MDAPs.

Most of the programs we looked at began during those two decades, and the reform efforts generally failed to deliver the promised results, in fact more often damaging the programs to which they were applied. Of particular note, highly optimistic assumptions about the cost-saving benefits of acquisition reform initiatives that were reflected in early cost estimates have proven to result in high cost growth when the reforms failed to deliver. When such an outcome is a clear risk in the assumptions used in the service cost estimate, the CAIG should reasonably be expected to raise a large warning flag (as in fact it clearly did for FCS).

In some cases the novel policies appear to have been adopted in hopes of accommodating external constraints on schedules or budgets, again without clear evidence that they were likely to be effective. In order to speed up the acquisition process, prudent early stages of program development and review were bypassed, and full-scale development or even Low-Rate Initial Production (LRIP) were initiated with inadequate levels of technology readiness.

Two reform initiatives that have played particularly strong roles in the programs we examined were "Cost as an Independent Variable" (CAIV) and Total System Performance Responsibility (TSPR). Under CAIV, once a well-defined and understood cost estimate for a program is decided on, the program manager should be tasked to manage to achieve that cost—i.e., cost is "independent"—not dependent on other program parameters. While seemingly a logical way to control costs, the approach is fraught with difficulties, not the least of which is that of determining a sound cost figure at the beginning of full-scale development. Another difficulty of long standing is the general reluctance to give the program manager sufficient authority to make the cost-performance trade-offs that are essential to a successful CAIV approach – even within the ranges established for the Key Performance parameters (KPP).[51] TSPR was an Air Force

[51] This is usually not a simple matter. Requirements tradeoffs should be made within a process of careful coordination between the developer and the user.

initiative to provide greater overall responsibility to the contractor to execute the program, within wide latitudes, with a marked reduction in government oversight compared to previous programs. Several programs among our group suffered from the application of these two initiatives, including JASSM, Global Hawk, SBIRS, and LCS.

A common theme expounded by many proponents of acquisition reform was to reduce the government's perceived micromanagement of the defense industry, which also provided a rationale for reducing the DoD's supervisory acquisition workforce.[52] Some program management offices become little more than skeletons. Contractors were granted expanded powers and many reporting requirements were reduced or eliminated with no effort to fund expanded management and systems engineering by the contractors to compensate for the cuts in government input. For the programs in our sample, these initiatives made significant contributions to cost growth and schedule delays, in large part, because they prevented early detection and correction of problems.

The JASSM missile program was a virtual poster child of acquisition reforms popular during the mid- to late 1990s. As described in considerable detail in our JASSM appendix, a veritable cocktail of reform initiatives were applied to the program at the direction of the Air Force Acquisition Executive. This included the aggressive use of CAIV and TSPR and, as already noted, the abandonment of traditional military specifications and standards, such as missile reliability requirements. The contractor was also put in charge of all testing and given extensive authority to make trade-offs within nearly all aspects of the program in order to achieve highly aggressive CAIV objectives. A very lean PMO and relaxation of reporting requirements reduced government oversight to a minimum. Eventually, these initiatives proved highly problematic for the program. A very similar story unfolded for SBIRS, again detailed in an appendix, which also gives the full story on the use of TSPR.

Evolutionary Acquisition

Another area of poor policy implementation is Evolutionary Acquisition (EA). A "proper" EA strategy is perhaps best typified by the F-16 fighter program, wherein successively more capable "blocks" of aircraft were acquired in successive budget years, rather than seeking to build the "ultimate" fighter in the first tranche.

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52 Some have observed that the reduction in government oversight and management personnel paralleled a general reduction in overall defense acquisition funding after the Cold War. This study did not attempt to partition such causes.

Although EA has been DoD policy for a number of years, there are few examples of its successful implementation (there were none among our MDAP sample). Examples of poor implementation, on the other hand, abound. The 2003 version of DoDD 5000.2 defined two versions of EA—Incremental Development, under which requirements do not change, and Spiral Development, under which each "spiral" can have different (usually increased) requirements. The 2008 reissue of 5000.2 removed this distinction.

A number of our programs claimed to have utilized evolutionary acquisition strategies, but few appeared to have followed the evolutionary model as usually understood, or to have achieved the intended results. The basic principle is that development will proceed in a series of discrete increments, with each increment involving worthwhile performance enhancements of limited scope change and little risk.[53]

The Spiral Development version has caused the most problems. Of the programs we examined, Global Hawk is the most notable example. Under the rubric of Spiral Development, the program expanded requirements in an uncontrolled way and permitted excessive concurrency in the needed development, testing, and low-rate production. LCS formally invoked evolutionary acquisition, but the program has not effectively used its evolutionary strategy to avoid risks or control costs. FCS is pursuing a modified EA approach, in that as the components of FCS reach maturity and readiness for production they are being "spun out" for application within the Army's combat brigades. This strategy, which was *not* the original concept at MS B, seems to have a reasonably good prognosis for success, if the technologies are shown to be sufficiently mature to warrant production.

Defective Contracting

The contractor's bid for JASSM, which served as the basis for the PM's cost estimate, offered firm fixed-prices for production of the first five lots, and provided for price increases thereafter. As pointed out in the CAIG report at MS II, the offer was on its face unsound: the cost of production for the first five lots was certain to be higher than the bid price. The first five lots were based on a low option price offer carrying a reasonably high risk that the government would not be able to exercise them, which in fact is what happened. The result was reduced quantities and procurement delays due to

[53] For a fuller and more authoritative description of the policy see DoD Instruction 5000.02 of Dec 8, 2008, p. 13.

reliability problems, eventually resulting in the loss of the low option prices. The JASSM story is thus an amalgam of mandated costing, poor management, and overly zealous use of acquisition reform initiatives that gave excessive authority to the contractor.

c. Poor Contractor Selection, Oversight, and Incentivization

We found cases in which the contractor's management and technical capabilities proved to be significantly deficient, where the program office and/or DCMA oversight was inadequate to identify and correct problems, and/or the contractor incentives were not well aligned with the government's interests. Some of these problems seem to be associated with the misguided acquisition reform efforts discussed above--relating to efforts to reduce burdens on contractors and empower them to take more responsibility and control. Unfortunately, this is not always a realistic policy, and the acquisition system has not been consistently effective in identifying the extent to which it can be beneficial in particular cases.

In the LPD-17, Global Hawk, ARH, and SBIRS programs the contractors selected were not fully ready to do what the program required because personnel with appropriate skills and expertise were not assigned to the program and/or critical tools proved inadequate. In all of these cases, the government's range of choice was limited by a paucity of bids. In the LPD-17 and SBIRS, competition was inherently limited by an industry that had consolidated to the point where very few sources remained. In the case of the ARH, the failure of several potential competitors to bid was attributed to unduly restrictive KPPs (a requirements issue) and/or unrealistic cost objectives.[54] Regardless of the cause, selection of an inadequately-qualified (SBIRS) or ill-prepared (ARH) contractor invariably resulted in a difficult and costly "catch-up" period and less-than satisfactory, or in case of ARH, results so untoward that the program had to be cancelled.

Poorly designed incentives, misuse of risk-sharing in development contracts, and conflicts of interest were also issues with the JASSM contract.

Many of the programs we surveyed suffered from weak oversight and contractors support. Specific examples include JASSM, SBIRS, ARH, LPD-17, EFV, and LCS. Program office staffs were small and heavily weighted with non-governmental support contractor personnel. The result was that program managers often did not become aware

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[54] In a post-mortem industry-government session after program cancellation, the contractor was asked what he would have done different. The answer: not bid.

of problems promptly and had limited resources to deal with them when they did become apparent. We found evidence that this situation was exacerbated by the relaxation in contractor reporting requirements due to acquisition reform efforts.[55]

More generally, these examples identify the difficulty that government source selection authorities have in accurately ascertaining the reasonableness of the contractors cost estimates when evaluating bids for cost-type contracts. Similar uncertainties underlie assessments of contractors' technical and management ability to execute their proposed development program. Such source selection problems were exacerbated by the loss of government expertise that resulted from the reductions in the government acquisition work force during the 1990s.

2. Weaknesses in Initial Program Definition and Costing

Our second major cause of acquisition cost growth seems obvious: if a program's initial cost estimate is erroneously low, future cost growth is virtually assured. While it is likely that there are, as many believe, cultural reasons for why initial program cost estimates tend to be low, those reasons are difficult to document. Instead, we sought to determine whether, and if so why, the initial estimates on the programs we examined were unrealistically low.

Before going into detail, it is useful to note that underestimating initial program costs is very common in projects of all kinds throughout government and industry, a conclusion which is beyond our scope, but substantiated by a large body of literature.[56] Management scientists and organizational psychologists have developed extensive literature on this phenomenon, ascribing it to fundamental cognitive distortions in the thinking of humans generally and the political factors they engender. Rational choice economic theorists acknowledge the phenomenon of widespread optimism in estimates while seeking to locate it as a rational response to underlying incentives.[57] Although we

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55 These conclusions come from our interviews. It was beyond our scope to delve into the details of the contractual relationships and government oversight of the contracts for the programs examined. Thus we cannot, in general, draw firm conclusions regarding how "blame" for bad outcomes should be assigned between the contractor and the government.

56 See for example, Flyvbjerg, Holm, and Buhl, *Underestimating Costs in Public Works Projects*, Journal of the American Planning Association, Summer 2002.

57 This literature is far too voluminous to cite even in summary here. Recent papers which contain references to earlier studies include Jean-Pierre Benoît, Juan Dubra, and Don Moore, "Does the Better-Than-Average Effect Show That People Are Overconfident?: An Experiment," MPRA Paper 13168 (Munich Personal RePEc Archive, Feb 2009) http://mpra.ub.uni-muenchen.de/13168/; Markus

focus on more specific causes, it should be remembered that these underlying factors are at work and should not be neglected. Our policy recommendations are consistent with those advocated by experts in this area of study.

Problems with initial cost estimates begin with the derivation of the SCP and the ICE (after CAIG review), as described in the Introduction. For most, if not all, of the programs we examined in detail it was evident in retrospect that the initial MS B cost estimates were unrealistically low (that is, even before considering subsequent unforeseen events).[58] Our review found no single dominant cause for this phenomenon.

CAIG Estimates and Cost Growth

The programs we studied reveal that funding to the CAIG estimate would not have eliminated reportable cost growth. Despite better overall performance when compared to the SCPs, the CAIG's estimates were sometimes significantly in error.[59] When this occurs, the entire decision-making process is put at risk, including both the original cost-effectiveness rationale and the subsequent stability and executability of the program.

It is not possible to produce a realistic cost estimate for a poorly defined program. If there is one prevailing reason for low initial cost estimates, both Service and CAIG, it is a lack of accurate, sufficiently detailed, and complete information about the program,

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K. Brunnermeier, Filippos Papakonstantinou, and Jonathan A. Parker, "An Economic Model of the Planning Fallacy," NBER Working Paper No. 14228 (National Bureau of Economic Research, August 2008) http://www.nber.org/papers/w14228; Bent Flyvbjerg, Massimo Garbuio, and Dan Lovallo, "Delusion and Deception in larger Infrastructure Projects: Two Models for Explaining and Preventing Executive Disaster," *California Management Review* 51, No. 2 (Winter 2009): 170-93; and Dan Lovallo and Daniel Kahneman, "Delusions of Success: How Optimism Undermines Executives' Decisions," *Harvard Business Review* 81, No. 7 (July 2003): 29-36. Earlier papers of fundamental importance include Roger Buehler, Dale Griffin, and Michael Ross, "Exploring the 'Planning Fallacy': Why People Underestimate Their Task Completion Times," *Journal of Personality and Social Psychology* 67, No. 3 (Sep 1994): 366-81; Roger Buehler and Daniel Kahneman, "Timid Choices and Bold Forecasts: A Cognitive Perspective on Risk Taking," *Management Science* 39, No. 1 (Jan 1993): 17-31; James G. March and Zur Shapira, "Managerial Perspectives on Risk and Risk Taking," *Management Science* 33, No. 11 (Nov 1987): 1404-18; Amos Tversky and Daniel Kahneman, "Judgment under Uncertainty: Heuristics and Biases," *Science* 185, No. 4157 (27 Sep 1974): 1124-31.

58 This is not surprising, since our selection of the 11 programs was not a random sampling; rather, we deliberately chose high-visibility programs that had experienced substantial cost growth, as measured from the Milestone B estimate.

59 This finding is consistent with previous IDA research, as reported in McNicol et al., "The Accuracy of Independent Estimates," IDA Paper P-3989. Some of the programs included in this report's sample have suffered significant increased cost growth since its data cutoff date and this will tend to increase the degree to which the ICEs and SCPs fall short of reality.

to permit a reliable cost estimate to be developed. This problem is closely associated with the immaturity of the system design, the critical technologies, or both. At the time of the estimate, even the sponsor may have an inadequate or erroneous understanding of how the actual program is likely to unfold. And as discussed earlier, when the initial stages of program development, as specified in DoDD 5000.02, are bypassed, it is less likely that the program will be fully defined and critical technologies matured at MS B, and thus that the initial cost estimate will be reliable.

Similar errors occur when highly optimistic assumptions about the cost-saving benefits of acquisition reform initiatives are made in the SCP, without direct supporting evidence.

In the case of the Joint Strike Fighter (JSF) program, lack of adequate program definition led the CAIG to underestimate costs. The ICE was based on early assumptions about airframe weights, materials content, the amount of engineering effort needed to develop a viable design, and how much commonality could be achieved across disparate variants. The CAIG's information on these matters came largely from the JSF program office, and it lacked, for the most part, any means to verify the information independently. Thus, although its procedure for estimating costs was independent, it did not have sufficient independent engineering information when producing the estimate. APUC is currently estimated at 42% over the CAIG estimate at MS B, and most of that growth can be attributed to lack of sound engineering information on which the CAIG's cost estimates could be based. Other cases where the program costed by the CAIG differed considerable from what was actually acquired include the LCS, Global Hawk, FCS, and to a lesser extent, ARH.

Much of the FCS program coming into MS B was conceptual and realistic costing was simply not possible.[60] For example, there was virtually no specificity with regard to the intended new family of lighter-weight armored vehicles (the initial weight objectives proved highly unrealistic) and the broadband communications network envisioned was just that—a vision. The CAIG initial RDT&E cost estimate was 34% higher than the SCP, while the procurement cost estimate was 15% higher. (The latest estimate before cancellation of a large part of the program indicated cost growth of 50% in RDT&E and

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60 The CAIG report at MS B for FCS, which is referenced extensively in the FCS annex, makes this point in no uncertain terms.

66% in procurement, but those comparisons are confounded by numerous changes in scope, both increases and decreases, over the course of the program.)

SBIRS presents a number of serious program pathologies that have contributed to more than a 250% unit cost growth, even with reduced scope and content. At program initiation, the estimated cost, which was in the $10 billion range, was considered unaffordable in the context of other Air Force priorities, prompting an intensive effort to find less costly approaches—without sacrificing desired performance. One of the major proposals to reduce costs was to introduce "commercial practices" in the management and execution of the program. It was also expected that use of commercial components, together with a predicted large increase in demand for commercial space systems, would bring great economies of scale and overhead dilution. Participants told us that savings of 20% or more were envisioned as a result, and these rosy projections found their way into the SCP and CAIG estimates. Scarcely any of those optimistic visions turned out to be accurate. The commercial market fell far short of projection and, as documented in the appendix on SBIRS, "streamlined" management contributed directly to program problems, imposing costs rather than savings.

Costing to Available Funds

An especially damaging practice for some SCPs has been costing programs on the basis of what will fit within projected program resources, rather than on the objective cost implications of the program plan and technical content.

The worst of our 11 examples is the LCS. The Service chief, intending to support a building program consistent with the Navy's fleet sizing goal and likely budgets, dictated the system's unit cost, apparently without due consideration of the impracticality of meeting that cost for an operationally viable warship with the desired capabilities. The cost cap imposed by the Chief of Naval Operations (CNO) was set at less than half of the original estimate by the Navy's ship cost group and was nominally based, as described to the CAIG, on a largely commercial vessel, essentially a coastal fast ferry with crew accommodations, carrying weapons modules in place of vehicles. The original SCP and CAIG estimates indeed turned out to be less than half of the currently estimated cost because the Navy's functional requirements for the ship to deploy to distant theaters and operate largely independent of local support, survive moderate levels of weapon damage, and integrate its modular weapons and sensors could not be met within the mandated cost or size constraints, or on the desired schedule. In essence, while the Navy said initially that it wanted a ferryboat, in the end it insisted on getting a warship, and found that it

could not get one for a ferryboat price. The industry, however, took the Navy's original statements and cost targets at face value and submitted bids based on commercial ferry construction practice. Since their estimate was not supporting an MS B decision, the CAIG did not prepare a formal ICE and simply accepted the industry bid numbers as generally reasonable, providing no formal warning of the large cost growth to come.

The story is somewhat similar for the now-cancelled ARH. There was funding available from cancellation of the RAH-66 Comanche program, so the Army decided to invest in a new helicopter based on an off-the-shelf commercial product. The intended unit cost of the LRIP aircraft was actually specified in the Request for Proposal (RFP) – in essence a "design to price" acquisition strategy. The winning design was based on the Bell 417, a planned commercial upgrade of the Bell 407 helicopter. But the 417 did not go into production, so all the cost estimates based on assuming it would became invalid. The MS B CAIG cost estimate accepted the Army's assumption that the ARH would be a modified version of the yet-to-be-built commercial 417 and was reasonably close to the SCP, giving no warning that the costing actually contained a large element of risk. This was not so much a quantitative error in initial costing as much as a failure to identify a significant risk implicit in that estimate.

Several other programs, notably EFV and SIBRS, suffered from the "cost-according-to-available funding" syndrome, usually also associated with extreme optimism regarding achievable economies or shortcuts. For those programs the actual funding was set at levels substantially below what was realistic or what was necessary to carry out the planned development effort, forcing deferral or shortchanging of some tasks. Bidders responding to RFPs are almost invariably aware of the budgetary limitations under which the program is being initiated and are thus under pressure to bid in line with Service cost expectations.

It could be argued—though the Nunn-McCurdy Act says otherwise—that inaccuracies in initial cost estimates should not be "scored" as real cost growth, but simply as erroneous costing: that so long as DoD gets value for the money, it is not so important whether the initial estimate was right or wrong.[61] Although such an outcome is

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61 JASSM is an example among the programs examined; despite the program's cost overrun and reliability difficulties, the missiles have been deployed and provide a capability that could be very valuable in certain high-threat scenarios.

certainly preferable to DoD spending a lot of money on systems that turn out poorly,[62] as noted earlier there are many adverse ramifications:

- The original cost-effectiveness assessment of the new system is called into question;
- There is a disruptive impact throughout the program/budget system (particularly on other acquisition programs);
- The credibility of DoD with the Congress and the public is diminished; and
- Excessive management attention is needed to address cost growth issues—re-baselining, Nunn-McCurdy breaches, etc.

When the true costs of acquiring a system that is seriously exceeding its initial cost estimates become manifest (and that manifestation seldom occurs all at once—it becomes apparent only over an extended period), several outcomes can occur:

1. The program may be cancelled (e.g., ARH), so the government has wasted much if not all the money put into it before cancellation, and the user has to do without an important capability until a new program can be executed; Such cancellations are very rare;
2. The higher costs are determined to be worth meeting without undue delay, resulting in a squeeze on other programs to pay for the overage; or,
3. What most frequently happens, the program is stretched out to fit within available resources—almost always with the necessity of at least some additional funding to cover the longer period, unless planned quantities are significantly reduced.

The cost inefficiency in the latter two cases has been estimated to be *at least* 2% to 8% of the entire acquisition budget—some $2.6 billion to $10.4 billion annually at current levels, resulting from extensions of RDT&E contracts and/or lower production rates over a longer period.[63]

a. Defective and Unstable Requirements Processes

Establishing clear, affordable, and cost-effective requirements has been a longstanding problem for the DoD acquisition process (and indeed for all DoD resource allocation processes). It is beyond the scope of this study to discuss in detail all of the

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62 Program cancellation may be the best of poor outcomes; worse still is to field systems that aren't capable, or are only marginally capable of performing the mission, or with costs to operate and support that exceed their value.

63 McNicol, "Cost Growth in Major Weapon Procurement Programs," IDA Paper P-3832, pp. 79-87. The author warns that the cost might well be even greater than 8%.

problems with the acquisition requirements process; however, deficiencies in the process were key factors in cost growth for several of the programs we studied. In those cases, requirements appear to have been established without adequate evaluation of their risk and cost implications, imposed by top-level fiat without adequate analysis of real need or cost-effectiveness, or changed radically in the course of the program without a full understanding of the impacts.

For most of the programs in our sample, there was little or no evidence of early studies examining tradeoffs of system-level requirements against cost (or, equivalently, against the quantity that can be afforded at a given budget level) or risk, although some tradeoffs became necessary as cost or technological realities undermined the original program plans. In several cases, risks or added scope associated with poorly analyzed requirements have been major drivers of cost growth.

One clear illustration is Global Hawk. The Air Force initially opposed OSD's initiative to start a program of record based on the DARPA ACTD. Once it was forced to begin, however, the Air Force embraced a much more ambitious version than OSD had envisioned and approved. MS II approval to enter into SDD was based on the DARPA ACTD program that included only one major sensor suite per aircraft. Almost immediately after the milestone decision, however, the Air Force initiated a study of sensor requirements that resulted in a 50% increase in the payload required of the air vehicle. Gross underestimation by the contractor and the government of the changes in airframe design that would be required led to a spiral of cost increases—increases that were further exacerbated by other factors discussed elsewhere in this report. Given such a major increase in system requirements, the appropriate course may have been to proceed with more production and fielding of the "A" model, a smaller and simpler air vehicle based closely on the ACTD design, as planned at MS II, until the requirements for a larger vehicle could be more fully defined and its design and cost impacts thoroughly understood. If the larger vehicle could, in fact, be justified, a new program could have been initiated as it had for Predator B (another remotely manned ISR aircraft).

We have already mentioned the case of the LCS, where lack of clarity about requirements led to confusion about the basic nature of the ship, and as a result the doubling of both cost and the duration of development. In the ARH program a requirement that two helicopters fit within a C-130's cargo compartment, sharply narrowing the potential field of competition, was adopted, apparently without formal consideration of the implications or possible alternatives.

In the JASSM missile program, in the name of acquisition reform, traditional military specifications and standards, such as missile reliability requirements, were abandoned. Instead of specifying a stand-alone reliability requirement, the JASSM program relied on a broader and unproven approach to performance-based requirements that relied heavily on modeling and simulation to determine "Missile Mission Effectiveness" (MME) and the "probability of reliability growth." This approach assessed only the product of three parameters, lethality, survivability, and reliability; although there was no lower bound or minimum requirement for any one parameter. The missile excelled at the first two parameters, but has (so far) failed to achieve the level of reliability considered acceptable to the operators. Although the contractor met the program's effectiveness objective as defined by the "MME," DOT&E subsequently deemed the missile's reliability as inadequate. Thus, a reliability requirement was added retroactively to the program. The entire episode contributed very substantially to cost growth in both the RDT&E and procurement costs.

JTRS-GMR originally had a fairly simple and clearly defined requirement to develop a low-cost radio system with software-defined waveforms to replace a variety of existing tactical radios, using commercial technology. Before MS B, however, the requirement was revised to include development of an ad-hoc battlefield tactical network – essentially a secure and reliable broadband cellular communications system on the battlefield, without cell towers. This has led to substantially increased costs and schedule slippage, and its feasibility remains in doubt, but it was adopted without apparent serious review of the consequences. Moreover, the interoperability benefits originally envisioned for the program have not been obtained.

Notwithstanding the evidence presented above, it is important to acknowledge that some requirements changes can be shown to be justified. For example, the emerging availability of new technology may well permit the fielding of a much more effective or reliable system at only modest increases in development cost. Financial reserves for such eventualities would be a significant aid to program stability.

b. Entry into Development with Immature Technologies

Another well-settled basic principle of sound acquisition planning is to ensure that all technologies critical to the eventual performance of the intended system have reached an adequate level of maturity *before* the full project is approved for entry into full-scale engineering and manufacturing development. However, few of the programs we examined came close to meeting that standard. Only a small fraction of the key

technologies were sufficiently mature, yet the FCS, SBIRS, JTRS-GMR, and WIN-T programs were approved to proceed into development. In some cases this may have been to avoid the appearance that the Department was losing momentum on initiatives that had high level support. Even if individual technologies are properly assessed as ready to support full-scale development, integration is critical at the system of systems level, and currently there is no assessment made of the readiness of technologies to achieve that integration. This issue is closely related to shortfalls in front-end systems engineering, discussed in the next sub-section.

Despite the requirements of DoDI 5000.2, most of the systems in our sample failed to demonstrate the required technology readiness levels (TRLs) for all their technologies prior to MS B, and some did so egregiously. FCS, JTRS-GMR, and WINT are the most extreme examples of the problem. In a May 2003 memorandum reporting on a review of the Army's Technology Readiness Assessment for FCS, the Director, Defense Research and Engineering stated that 24 of the 31 identified critical technologies were at TRLs below 6, but MS B was approved anyway. In February 2009—six years later—the Army stated that four critical technologies were still at TRLs below 6. Furthermore, those four technologies were at the heart of the "mobile ad hoc network" needed to achieve the capabilities on which FCS is premised. JTRS-GMR successfully passed MS B with *none* of its 20 critical technologies at the TRL 6, and some below TRL 4. And WIN-T had only 3 of 12 critical technologies at the TRL 6.

The ARH was another, somewhat different, example. Since the acquisition strategy envisioned a modified commercial off-the-shelf (COTS) helicopter, the Army was permitted to go directly to MS B. There had been no Concept Decision (CD) or Materiel Development Decision (MDD) or MS A review, and no systematic Materiel Solutions Analysis (MSA) or Technology Development (TD) processes, or their equivalents. After MS B, the Army decided to substitute the Target Acquisition Sensor System (TASS) for the sensor system originally selected by Bell Helicopter, even though there were technology readiness issues with TASS. In subsequent user testing, the system experienced a major failure.

c. Deficient Front-End Analysis of System-Level Design Issues and Technical Risks

Many of the programs we examined showed evidence of inadequacies in initial systems design, systems engineering, and risk assessment. Those inadequacies translate

directly into unreliable initial cost estimates because they are a reflection of poor program definition.

Systems Engineering Shortfalls

A common theme in our case studies was the notable lack of systems engineering discipline before these complex programs entered full-scale development. Without the comprehensive allocation of work effort that results from sound systems engineering, realistic scheduling and material and labor cost estimating was essentially impossible.

The deficiencies in early systems engineering we observed resulted in part from the effort to sharply limit spending in the early years of program development. Systems engineers are expensive and scarce and, under historical policies and practices, not considered highly essential in the early phases of program definition. These shortfalls in early systems engineering shortchanged MDAPs both at the program-office/commodity-command level and at the OSD review level, where there has been a dearth of experienced systems designers capable of providing and supporting the type of independent cost review provided by the CAIG.

The results of these deficiencies in early systems engineering included serious underestimation of the scope of the required development effort, a failure to identify key risk areas that warrant extra effort, and requirements-design mismatches. These factors, individually and collectively, invariably led to high cost growth relative to initial estimates, at least for development and probably for production as well. This is a problem that extends far beyond the commonly-cited defects in front-end systems engineering processes. Almost without exception, the cases we examined have involved underestimation of the systemic risks related to the design as a total system, beyond the risks associated with particular technology elements. This has contributed greatly to the underestimation of costs and schedules and, in several cases, has led to major and costly development problems.

As observed earlier, many of these programs have fallen short of TRLs required prior to entry into full-scale development. A separate problem lies in inadequate analysis of design issues and integration risks at the system or system-of-systems level, contrasted with individual technology areas.

The WIN-T and JTRS-GMR are two examples. Both were premised on an assumption that communications architectures available or being developed in the commercial sphere would serve very different military needs, without adequate

engineering analysis to determine how realistic those assumptions were.[64] In fact, both programs have proven to involve major unforeseen challenges, have been substantially restructured, and have experienced large cost and schedule overruns.

Another major example is JSF, where delayed recognition of the overall design and integration issues associated with the unprecedented supersonic STOVL variant led to a crisis halfway into SDD that threatened the viability of the entire program and forced design changes resulting in major increases in development and production costs. At the time of MS B, weight growth was forecast to be toward the bottom end of the historical range, based on the use of advanced design tools. Only after critical design review (CDR), when design and construction of prototypes were well advanced, was it recognized that the weight growth was, in fact, well above historical norms, and at a level that would make it impossible to meet operational requirements. This led to a very costly redesign and lengthy delay. More thorough early systems engineering would have identified the extent of the weight risk much earlier and in doing so avoided a great deal of cost growth and delay through more accurate budgeting and scheduling.

SBIRS is a particularly striking example of inadequate early systems engineering. Because the potential to correct problems is so small once satellites are launched, space programs have traditionally engaged in especially intensive systems engineering in their early phases. The government maintained its own high-level systems engineering capabilities, both in-house and at FFRDCs, in addition to requiring contractor systems engineering efforts. But SBIRS, notably, lacked systems engineering efforts by the government or by the contractor, and as a result many very costly problems emerged long after they should have.

In the ARH program, as already noted with regard to initial costing, there was a failure to recognize the substantial risks associated with selecting the Bell 417 commercial helicopter as the basic platform for ARH. The 417 was in development at the time of the contract award; however, it was cancelled because a commercial market analysis failed to support going into production. Despite that unexpected development, the program continued to try to execute an already ambitious schedule. With the cancellation of the 417, the planned production line, which had been projected to be producing commercial helicopters at a substantial rate, moved from Canada to a

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64 According to GAO, at least two studies were available at the time indicating that the assumption was faulty.

production facility in Texas that had much higher labor and overhead rates and was not producing new helicopters at the time. A more deliberate front-end analysis could have at least revealed that risk. Poor systems engineering also affected the program. After the contract award, the Army decided to use different mission equipment and other components than originally proposed by Bell. Some of those components had technology readiness issues (as noted above) and some were not well-suited for the ARH airframe design. These issues could have been sorted out and risks more clearly identified by a more deliberate early systems design review.

Virtually every program we surveyed experienced costly problems that could have been avoided or ameliorated through better front-end analysis of overall design issues and risks. Serious attention to system-level risk seems to have been lacking on the part of senior decision-makers.

Inadequate Recognition and Hedging of Program Risks

In too many cases major program risks have not been clearly foreseen or hedged against. And when risks have been identified, the response has often fallen short. There are examples in practically every MDAP we reviewed, but we will focus on three.

Because space systems require very low weight, very high levels of performance, and very high levels of reliability, recognized best practices call for parallel development of two or more alternative approaches to critical components or subsystems. In many of these areas, however, the SBIRS program followed a single-threaded approach. The result was that several major efforts failed to yield the necessary results, forcing program stretch-outs for replacement developments that resulted in major growth in development costs.

As noted earlier, the JSF program assumed that weight growth over the course of EMD would be at the low end of the historical range for fighter programs in general. When this proved to be seriously optimistic, the consequences were even more severe than those of excessive weight growth in normal aircraft programs because the STOVL variant was so weight-critical. Of course, it would have been possible to anticipate that there was a risk of greater-than-hoped weight growth and that if this occurred it would endanger the program, but warnings to this effect were not acted upon or incorporated in program planning. As a result, when recognition of the weight growth finally did come, after the critical design review, it forced a costly major reorientation of the development program, and scrapping of much of the previous work.

The JTRS-GMR program proceeded into uncharted waters by trying to develop a mobile ad hoc communications network that could function effectively in the environment of ground combat operations without recognizing or hedging against the large technological risks. The result was a five-year extension in the R&D program and commensurate delays in being able to produce the radios needed for forces deploying to ongoing operations. Instead, large numbers of legacy radios were procured, thus foregoing the interoperability benefits the original JTRS-GMR was supposed to achieve.

In the late 1960s and 1970s, effective systems engineering technical oversight was frequently provided by the predecessors of AT&L (which had various titles that changed over time). The organization employed a significant number of well-qualified engineers and the leadership, also technically-oriented, understood and accepted their advice and were more proactive in program oversight. That model faded in the 1980s as a result of increasing concerns about conflicts of interest (which limited the circulation of senior engineers between industry and government), and a growing belief that OSD should leave technical matters to the Services and industry. But today, even the Services lack technical expertise in the government workforce —one of the unfortunate consequences of the major reductions in the acquisition workforce in the late 1990s. Several programs we examined exhibited these affects, namely FCS, JASSM, SIBRS, and Global Hawk, and probably ARH as well. For FCS, the Army had to turn to a "Lead Systems Integration" contractor to oversee the entire program and perform many of the functions normally performed by the Government.

d. Excessive Schedule Compression and Concurrency

Most of the programs examined had some form of schedule compression and/or concurrency during at least some phases of the program that was justified on the basis of speeding the delivery of desired capabilities and/or cutting costs by reducing development and production spans. Unfortunately all too frequently, these measures have backfired and actually resulted in later deliveries and/or higher costs than might otherwise have been the case. The lack of robust early systems engineering contributed to generally unrealistic hopes that the development schedule could be more compressed than was the case for previous successful developments. The result was excessive concurrency without adequate risk mitigation funding and inadequate developmental testing, leading to the need for rework and retesting.

Extending the development, program delays, or reduced quantities in production always increase unit costs because overhead expenses continue for longer and are

allocated over fewer units. It usually means more direct labor as well, at least in development, thus further increasing costs. Thus underestimates of required time spans generally go with underestimates of required resources, but the damage can be even greater if capabilities really needed by the user are not delivered as planned.

A clear example is the LCS program, where a highly aggressive, success-oriented schedule for the first prototype ship resulted in a great deal of re-done and out-of-scope work when the full needs of a warship development program were recognized. The resultant costs were substantially greater than they could have been if the schedule had been realistic to begin with. The EFV's critical design review was held immediately following EMD contract award, before tests of the technology prototypes had been completed or fully analyzed. As a result the design of the EMD prototypes did not incorporate important lessons subsequently revealed in testing, not only resulting in downstream rework but also contributing to the ultimate failure of the EMD.

LRIP for the larger variant of Global Hawk (RB4B) commenced before the designs were stable and long before sensor packages were fully developed and ready for integration, resulting in extensive rework, not only increasing costs but further delaying deployment of critical operational needs. In the case of JASSM, the original development program was curtailed (reducing both the length of time that competition was maintained and the time available to mature technology and production processes), contributing to missile reliability problems, rework, schedule slippage, and cost growth.

The grave weight problems of the JSF were discovered only after CDR. By then much had been invested in components for EMD prototypes that had to be scrapped or extensively reworked in order to achieve flyable weight. Moreover, there had already been considerable work to develop the details of designs that had to be discarded and restarted.

The initial systems engineering inadequacies for ARH had a compounding effect in that the development schedule was highly compressed because of a perceived urgent need and the assumption that the development could capitalize on a soon-to-be-available commercial helicopter and military components from other programs. Even if all the going-in assumptions had been met, the schedule was extremely success-oriented. Then, as previously noted, the Army directed major configuration changes after MS B and Bell had cancelled the 417.

B. OTHER OBSERVATIONS

This section discusses four problems areas for DoD acquisition programs that, while important in their own right, are more secondary causes of cost growth in the programs we examined.

1. Lack of or Problematic Competitive Prototyping

Competitive prototyping was a notable feature of many aircraft acquisition programs in the two decades prior to World War II.[65] This practice was particularly essential because aircraft performance often fell short of predictions in that period. During World War II competitive prototyping went into partial eclipse, and it was only partly revived in the years following the war. With aircraft costs rising rapidly and performance predictions improving, full-scale competitive prototyping was used only sparingly in the late 1950s and 1960s.

A series of poor outcomes in aircraft and other programs led to a revival of prototyping as a policy, under the rubric of "fly-before-buy," early in the 1970s. It was not without its critics, however, and late in the decade a task force of the Defense Science Board (DSB) warned that

> The widespread or mandatory use of full-scale system prototypes for all programs up to the production prototype level is frequently wasteful of critical national resources—dollars and manpower as well as time. There are examples in recent programs (e.g., A-10/A-9, F-16/F-17) where little benefit can be found in the use of prototypes in terms of shortening the development cycle, reducing overruns, reducing overall cost, or minimizing risk.[66]

It is important to note that the criticism is restricted to competitive "full-scale system prototypes." The use of engineering test articles to prototype and test specific features that involve significant unknowns or risks is of undisputed value. What was questioned was the need for complete aircraft, or their equivalents in other fields, which tended to be far more costly and time-consuming to build. Many systems engineers and engineering executives questioned the return on such investments. The overall thrust of the advice from the DSB and other authoritative sources has been that competitive

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65 "Competitive prototyping" must be distinguished from development prototyping. Thorough testing of full-scale prototypes closely representative of the final production article is a necessity in the development of virtually any program involving substantial system-level risk where series production is contemplated. In most cases competitive prototypes are constructed long before the final production configuration has been fully defined and represent only aspects of the final design.

66 Defense Science Board, *Report of the Acquisition Cycle Task Force*, 15 March 1978, p. 53.

prototyping can be a powerful and valuable tool, but that its application must stem from an analysis of the needs and the circumstances of particular programs.

Competitive prototypes between two firms were planned through all of Program Definition and Risk Reduction (PDRR)[67] and into the EMD phase of the JASSM program, but those plans were curtailed because of high costs and Congressional budget cuts. While the original Global Hawk aircraft approved at MS II (RQ-4A) was prototyped during its ACTD, the much larger RQ-4B model that was added to the program within months after MS II was never prototyped. It was erroneously assumed that there would be 80% commonality between the RQ-4A and RQ-4B. Those assumptions did not prove accurate and the gross underestimation of the complexity of moving to the RQ-4B resulted in significant cost increases and performance and schedule shortfalls in the program.

Based on our analysis, the use of competitive prototyping in the JSF and LCS programs does not appear to have been cost-effective. In both cases it is likely that the impact on costs exceeded the cost of the prototypes themselves; thus, competitive prototyping actually contributed to their cost growth. (But for JFS those costs were incurred before MS II, so any impact on post MS II cost growth, as recorded by the study, is purely conjectural.)

As previously discussed, weight was (and is) an especially crucial issue with regard to JSF. Any fighter aircraft development involves a struggle with weight, but the STOVL requirement made the aircraft still more sensitive to weight, while the three-in-one commonality requirement raised previously-unexplored questions about achieving the desired weight. The primacy of weight as a system-level risk factor posed challenges for the pre-MS II competitive prototyping program–challenges that were not met. To accurately replicate the weight of the production aircraft requires a prototype effort largely equivalent to that required for the late EMD pre-production prototypes, which is to say many hundreds of engineer-years and a great deal of engineering test effort, requiring one billion dollars or more in addition to the cost of prototype construction.[68] But the opportunity costs to the program were even greater. If the same sum had instead

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67 The term used for the pre-MS B phase of a program at the time.

68 Because the contractors contributed some of the cost (which became part of their cost basis for amortization in overhead burden on future contracts) there is no clear accounting of the final actual cost.

been devoted to probing weight issues through early systems engineering, the weight problems would likely have emerged much earlier in the overall development process.[69] The result would have been both a better basis for realistic cost estimates at MS II and partial or complete avoidance of the crisis that later emerged, with all the waste and delay that it precipitated.

The LCS program was initiated with the construction of two technology demonstrator ships built with RDT&E funds, designated LCS 1 and LCS 2. While these ships were intended to eventually be deployable, they can be considered, in effect, competitive prototypes. Built in great haste, the two initial units came in far over budget and behind schedule. It is not at all clear that the lessons learned in their early testing will translate into significantly less costly follow-on ships, thus calling into question their value as "competitive prototypes." All of this suggests that the more than one billion dollars spent on the two initial ships may not provide a particularly good return on investment.

2. Inadequate Affordability Assessments

As explained in the Introduction, DoDD 5000.02 requires that for a program to be approved at MS B for Engineering and Manufacturing Development the sponsoring Component must have programmed the full funding for the program in their POM.[70] Once that POM is reviewed and approved by the Secretary of Defense, the program will be fully funded in the DoD FYDP. Thus by definition, the program is "affordable" for the years covered by the FYDP; however, in most cases the FYDP reflects, at best, only early procurement costs for new MDAPs. When the major costs occur beyond the FYDP, as is usually the case, there is no real mechanism to assess the extent to which a proposed program will be affordable in the longer term, when other needs, overall DoD priorities, and likely fiscal constraints are considered.

The Defense Program Projection (DPP), while not an approved product of the DoD PPBES, does provide a context in which long-term affordability can be evaluated, although its utility is limited by the very fact that it is not "approved" and therefore not

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69 Because weight was so clearly a critical issue, this would have been a plausible application of added funds if they had been available.

70 The Component's POM will subsequently be submitted to and reviewed by OSD, which must verify that the program is still fully funded. Such verification must occur with each subsequent POM submission as well. If these verifications do not occur, there is no guarantee that the acquisition program is adequately funded.

authoritative. Nonetheless, consideration of the outyear affordability of a proposed program in the DPP context can provide useful insights into its affordability.

So, the reader might ask, what does affordability have to do with cost growth? The answer is that there is an indirect effect. If a program is initiated and later turns out not to be as affordable as planned, the program will have to either be modified or cancelled. If cancelled, the money already spent will have been wasted, and the requirement that the program was supposed to fill will go unsatisfied until another solution can be found. If modified, there could be a reduction in scope to make it affordable or the program can be stretched out to require less funding per year over more years (or both). Stretch-outs will normally be accompanied by substantial total cost growth, both from stretching the development program, as well as lowering production rates, which increases unit production costs.

Even more unfortunate outcomes can occur from attempts to execute seriously underfunded programs based on a "can do" spirit and the belief that shortcuts and "efficiency measures" can achieve the improbable. Such high risk strategies usually backfire, with unfortunate consequences in program execution and cost growth. Global Hawk, among the programs examined, was a particularly noteworthy case. The Air Force did not have sufficient funds to properly execute the program, once it had been decided to develop a larger aircraft with multi-sensor intelligence suites, and it was unwilling to take resources from other programs. Instead it attempted to execute the program with reduced funds, with predictably poor results.

FCS, if executed as defined at MS B, would have entailed huge funding requirements in the outyears beyond the FYDP – requirements that are significant when compared to total Army investment program. It is difficult to envision how those funding demands could possibly have been met. The only realistic expectation is that they would not have been, and that FCS procurement would be long deferred and/or stretched out. Either option would lead to substantial increases in costs, further exacerbating this program's already substantial cost growth. Affordability pressures could also still affect other large programs in our set, particularly JSF.

3. Utility of Reserve Budget Provisions

Many studies of the problems in defense acquisition have highlighted the lack of an explicit mechanism within the DoD for programming and budgeting financial reserves for unforeseen contingencies For complex defense system developments, such as is

normally the case for MDAPs, the ability to accurately estimate development and production costs is tenuous, even under the best of circumstances. Faced with such inherent and unavoidable uncertainties, it is good management practice to maintain a reserve of funds that can be drawn on to meet unexpected needs. If no reserves exit and the unexpected contingency arises, then the required funds might be taken from other, presumably lower priority, programs. That can be highly disruptive to those programs, resulting in stretch-outs of many programs and ultimately increased costs. Alternatively, the program in question can attempt to execute without additional funding by taking risky shortcuts, such as excessively concurrent scheduling, or curtailment of systems engineering and risk reduction efforts. Either approach will likely be detrimental, as we have seen in the programs we examined.

Our study of the eleven troubled programs did not explicitly identify lack of reserves as a significant problem. The problems encountered by each of these programs were, in most cases, so large and not of a nature for which the injection of any reasonable amount of "reserve" funds would have kept them on schedule. Indeed, most slipped primarily for technical reasons – not for want of funding. But they eventually needed more funding to be continued, and that funding may well have come from reductions in the funding of other healthier programs, but our research did not extend to examining such effects.

4. Cost Estimates for Development Contracts

Most new MDAPs involve years of "invention" activities with costs that can only be roughly approximated in advance. Furthermore, the cost of development is usually only a small fraction of the total cost for programs that lead to years – or decades – of production, such as most aircraft, ships, ground vehicles and expendable weapons. Both of these facts argue for a de-emphasis on contractor estimates of the development costs in the initial selection, in favor of emphasizing the likely quality of the development effort and the cost and performance of the resulting system when it reaches production.

But Congressionally-driven Federal procurement laws and procedures are sharply biased toward the comparison of cost bids – even for cost-reimbursable development contracts. Cost "shootouts" are perfectly reasonable when the government is purchasing known commodities or fully defined end items that require little or no engineering development. But picking development contractors based primarily on their own estimated development cost is highly risky. Some senior industry executives have gone

so far as to suggest that the government should ignore bidders' cost estimates when making an award, and concentrate instead on the proven quality of recent work as well as the innovative ideas and expertise that the contractor would bring to the program.[71]

Indeed, the government has attempted to move away from "cost shoot outs" towards "best value" contracting for complex development programs, but the frequency of sustained protests tends to inhibit this approach. A black and white cost comparison is certainly simpler, more understandable, and defendable to the Congress. But it doesn't always get the best results.

C. CONCLUDING REMARK

While each program we examined was afflicted by a unique cost-growth syndrome, together they support a unifying insight: cost growth in each of them could have been greatly reduced or eliminated if policies and procedures *previously developed and promulgated for that purpose* had been more rigorously enforced. In most cases, rigorous enforcement would have delayed the system's entry into (but not necessarily its completion of) development. In several cases it would have forced a system with expanded requirements to re-qualify for development. And it would have raised the standard of systems definition and systems engineering to levels that would have made reliable cost estimation practicable and successful development more likely. The recommendations presented in the next chapter are intended to re-instill the necessary rigor to the process.

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71 Report of the Defense Science Board/Air Force Scientific Advisory Board Joint Task Force on Acquisition of National Security Space Programs, May 2003.

III. RECOMMENDATIONS

The following recommendations are intended to help prevent, or least alleviate, each of the major causes of cost growth identified in our study. They are directly supportive of the goals established by the WSARA 2009.[72] These detailed recommendations flow from, but are not tightly tied to, specific causes identified in each of the case studies.

Several of our recommendations entail increasing the government's expertise in systems engineering and management – a process requiring more senior, experienced people. This appears quite feasible under the recently increased authorized size of the defense acquisition corps, but it will take years to complete. In the meantime, experienced people who are free of conflicts of interest can likely be "borrowed" for specific reviews from government laboratories, University Affiliated Research Centers, and Federally Funded Research and Development Centers, all of which are within the purview of the DAE.

A. IMPROVE DEFENSE ACQUISITION EXECUTIVE MANAGEMENT OVERSIGHT

The DAE should establish a greater sense of commitment and accountability among the leaders of the acquisition team through a formal process for tracking commitments made at DABs and at other OSD reviews. This process should include tracking the implementation of ADM directives in both contracts and budget documents. Tracking should become a regular feature of a revitalized DAES review process that is designed to identify MDAP problems early enough for the DAE to take appropriate corrective action. A useful top level outline of a tracking process is shown in Figure 2 below.

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72 Weapon Systems Acquisition Reform Act of 2009, Public Law 111-23-May 22, 2009, 111th Congress.

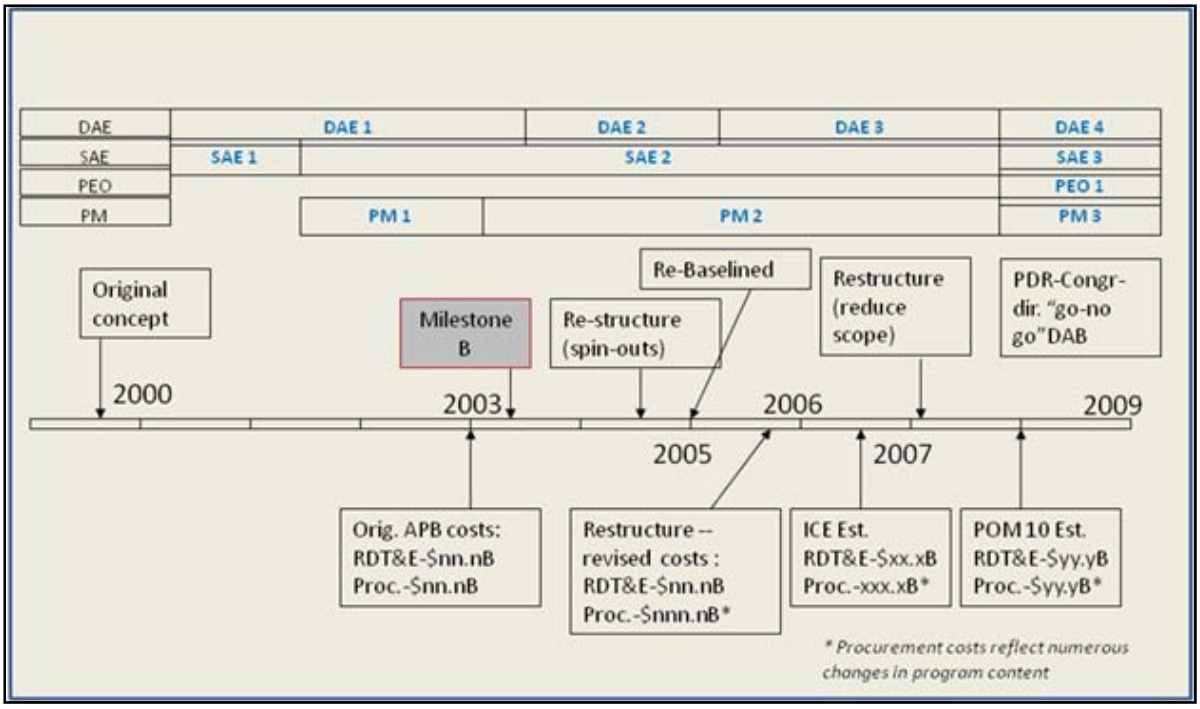

Figure 5. Template Used to Track Record of Progress for MDAPs

B. STRENGTHEN THE ANALYTIC BASIS FOR SETTING MAJOR DEFENSE ACQUISITION PROGRAMS REQUIREMENTS

The DAE should work closely with the Director CAPE to reinvigorate mission-area type analyses of the capabilities needed to meet the Secretary's defense strategy to identify both appropriate changes in ongoing MDAPs, and the key performance requirements of any new materiel needs. These analyses should include an appropriate range of materiel and non-materiel alternatives, including programs recommended by the DoD Components and by the Joint Staff. Essential to this analysis is sufficient technical expertise to permit accurate assessment of the feasibility, risks, and likely cost of any candidates proposed for new materiel solutions.

C. RENAME AND RESTART PROGRAMS WITH MAJOR SCOPE CHANGES

Whenever a major change is being considered for an MDAP, the DAE should conduct a DAB review that includes potentially renaming and formally restarting the program at an appropriate milestone with a new Acquisition Program Baseline and Selected Acquisition Report.

D. STRENGTHEN TECHNICAL OVERSIGHT

The DAE should establish a CAIG-like Systems Engineering Improvement Group to conduct independent reviews of the proposed design concept and development plan of new MDAPs. The group should comprise experienced systems designers, and the reviews should be scheduled early enough to help the CAIG by strengthening preparation of the CARD. One of its goals should be ensuring that the development funding plan is adequate to limit the risks at the next milestone to acceptable levels.

E. IMPROVE CONTRACTOR SELECTION

The DAE should strengthen the government's ability to assess the realism of contractor proposals for MDAP development and to make awards based on "best value." To this end, source selection for cost-type development contracts should de-emphasize the contractor's estimates of the likely cost in favor of an increased emphasis on the contractor's technical approach and overall qualifications and the government's estimate of the likely cost for that contractor to successfully complete development in a way that leads to affordable production costs. In addition the DAE should strengthen the qualifications of the government's pre-award survey teams.

Another step would be to strengthen the process for ensuring that only clearly qualified contractors are solicited for formal bids by increasing the use of the past performance database.

F. STRENGTHEN AFFORDABILITY ASSESSMENTS

To limit "over-programming" of MDAPs beyond the FYDP years and the resulting "bow wave" of unaffordable programs, the DAE should work with the Director CAPE to ensure that the DPP is updated at least annually. Then it should be used explicitly at each DAB to assess long-term affordability within the expected acquisition portfolio funding totals. The annual Program Objective Memorandum POM review should include an assessment of the longer-term affordability of the entire acquisition program, as well as a verification of the implementation of the DAB-approved funding plans for each MDAP.

G. AVOID UNPRODUCTIVE PROTOTYPING

Acquisition executives should ensure that full funding is provided for competitively prototyping of those elements of a new system for which such prototyping

can be shown to be cost effective. Do not rely on prototyping as a substitute for robust systems engineering.

H. AVOID INEFFECTIVE OR MISGUIDED REFORMS

When considering potential new "reforms" of the DoD acquisition management system, the DAE should first subject proposals to controlled trials on one or a few appropriate programs. Only when the data from such "pilot programs" have demonstrated the effectiveness of the intended improvement should consideration be given to the wider application of the reform. The results of prior reform efforts should be thoroughly assessed before failed approaches are reconsidered.

I. FINAL NOTE

Implementation of these recommendations will require no changes to existing legislation, and, with the possible exception of the creation of the SEIG, no major organizational changes within the Pentagon. Implementation will, however, require a considerable increase in the diligence with which the DAE, his staff, and other members of the defense acquisition team implement longstanding policies (as reflected in extant DoD directives) and best acquisition practices. Those practices are rooted in the report of the 1986 Packard Commission, have been expanded by numerous subsequent studies, and are further reinforced by the Weapon Systems Acquisition Reform Act of 2009.

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14. ABSTRACT

This study examined major causes of Defense acquisition cost growth by in-depth investigation of cost growth for 11 key Major Defense Acquisition Programs. The programs were: Amphibious Transport Dock (LPD-17), Armed Reconnaissance Helicopter, Expeditionary Fighting Vehicle, Future Combat System, Global Hawk, Joint Air-to-Surface Strike Missile, Joint Strike Fighter, Joint Tactical Radio System, Littoral Combat Ship, Space-Based Infrared System, and Warfighter Information Network-Tactical. The paper describes the history of the eleven programs and the events, and decisions that led to cost growth are documented. The study uses the results to draw conclusions about the major reasons behind cost growth in Department of Defense acquisition programs, and develops recommendations to limit such growth in the future.

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